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# *GEOMYDOECUS* (MALLOPHAGA: TRICHODECTIDAE) FROM THE TEXAS AND DESERT POCKET GOPHERS (RODENTIA: GEOMYIDAE)

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*Abstract.*—*Geomydoecus truncatus* Werneck and *G. quadridentatus* Price and Emerson are redescribed and illustrated. The new species ***G. neotruncatus*** is described, with the type host being *Geomys personatus streckeri* Davis.

*Key Words:* lice, *Geomys arenarius, Geomys personatus*

Since the initial revision of the pocket gopher lice by Price and Emerson (1971), most of the taxa of the louse genus *Geomydoecus* Ewing occurring on the host genus *Geomys* Rafinesque have been the subject of re-examination and further study and analysis. The principal works dealing with these lice are those by Price and Hellenthal (1975) on the *Geomydoecus texanus* complex, Price (1975) on the *G. scleritus* complex, and Timm and Price (1980) on the *G. geomydis* complex. This last work presents keys to the males and females of all *Geomydoecus* known to that time from *Geomys* gophers. It is the purpose of the present paper to complete the taxonomic study of lice from *Geomys* by considering the *Geomydoecus truncatus* complex from the Texas pocket gopher, *Geomys personatus* True, and the *Geomydoecus quadridentatus* complex from the desert pocket gopher, *Geomys arenarius* Merriam.

Quantitative data for the lice studied in this paper combined with host and locality information form part of a computerized pocket gopher-louse data base maintained at the University of Notre Dame. Counted or measured characters in the following descriptions are followed by the minimal and maximal observed values, and, in parentheses, the sample size, mean, and standard deviation. All measurements are in millimeters. In evaluating character usefulness for specific discrimination, critical values for each character were calculated at the point where the likelihood of single character misidentification of the two compared taxa was equal, given normality and equal variance, and ignoring the probability of collection. For characters offering moderately good discriminating ability, these critical values and the corresponding probabilities of misidentification are given. In an abbreviated comparative description for a species, quantitative data are given only for those characters whose means differ at a significance level of $P \leq 0.01$. The host distribution map was produced by a computer from a pocket gopher/louse association data base (Hellenthal and Price 1984). The map projection is rectangular to simplify determination of the latitude and longitude for individual collection sites. Original locality data expressed in miles are followed parenthetically by the metric equivalent to 0.1 km; the English figure, rather than the metric, expresses the precision of the location estimate. Abbreviations used for host accession numbers are KU (University of Kansas), TAM (Texas A&M University), and TT (Texas Tech University). Detailed descriptions of the characters and quantitative procedures used for *Geomydoecus* lice are included in Hellenthal and Price (1980).

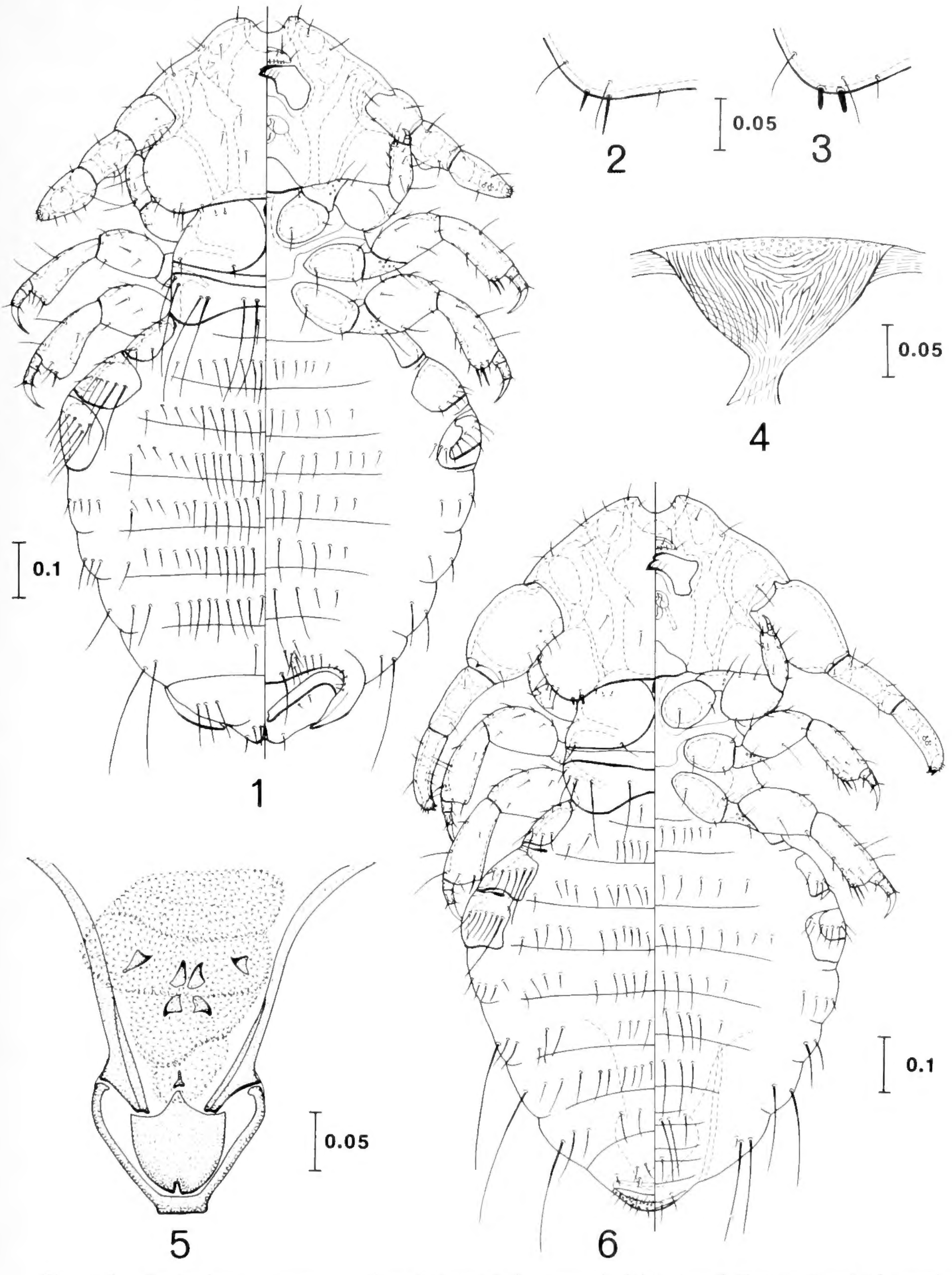
### *Geomydoecus truncatus* Werneck
Figs. 1–6

*Geomydoecus truncatus* Werneck, 1950: 13. Type host: *Geomys personatus personatus* True.

Male.—As in Fig. 6. Temple width (TW) 0.435–0.470 (26: 0.450 ± 0.0096); head length (HL) 0.325–0.360 (26: 0.338 ± 0.0089); submarginal and inner marginal temple setae 0.030–0.045 (15: 0.036 ± 0.0046) and 0.020–0.030 (24: 0.025 ± 0.0015) long, respectively, with submarginal seta positioned near inner marginal seta and both marginal setae blunt, spiniform (Fig. 3). Antenna with scape length (SL) 0.180–0.200 (23: 0.191 ± 0.0057), scape medial width (SMW) 0.110–0.125 (23: 0.119 ± 0.0054), scape distal width (SDW) 0.110–0.130 (23: 0.122 ± 0.0054); without projection on posterior margin. Prothorax width (PW) 0.320–0.345 (26: 0.330 ± 0.0069). Abdominal tergal setae: I, 2; II, 12–16 (26: 14.0 ± 1.18); III, 16–24 (26: 19.6 ± 1.68); IV, 19–25 (26: 22.3 ± 2.00); V, 16–25 (26: 19.9 ± 2.13); VI, 13–20 (26: 15.8 ± 1.83); tergal and pleural setae on VII, 18–22 (26: 20.5 ± 1.21). Abdominal sternal setae: II, 9–12 (25: 10.5 ± 0.96); III, 9–15 (26: 11.5 ± 1.30); IV, 11–15 (26: 13.2 ± 1.08); V, 8–12 (25: 10.1 ± 1.15); VI, 6–9 (24: 7.7 ± 0.85); VII, 6–9 (25: 6.9 ± 0.91); VIII, 4–8 (25: 6.1 ± 0.86). Total length (TL) 1.210–1.385 (25: 1.285 ± 0.0511). Genitalia as in Fig. 5; spinose sac with 6 medium spines; parameral arch flattened medioposteriorly, width (PAW) 0.140–0.160 (23: 0.154 ± 0.0057); endomeral plate broadly rounded, with small medioposterior notch, width (EPW) 0.075–0.090 (26: 0.085 ± 0.0037), length (EPL) 0.075–0.100 (24: 0.087 ± 0.0054).

Female.—As in Fig. 1. TW 0.475–0.500 (23: 0.483 ± 0.0073); HL 0.310–0.345 (23: 0.327 ± 0.0083); submarginal and inner marginal temple setae 0.030–0.050 (17: 0.037 ± 0.0055) and 0.035–0.045 (22: 0.040 ± 0.0031) long, respectively, with submarginal seta positioned near inner marginal seta (Fig. 2). PW 0.340–0.385 (23: 0.356 ± 0.0119). Abdominal tergal setae: I, 2; II, 14–18 (23: 16.3 ± 1.05); III, 20–25 (23: 22.4 ± 1.38); IV, 23–30 (23: 26.2 ± 1.95); V, 24–28 (23: 25.6 ± 1.08); VI, 21–25 (23: 23.4 ± 1.23); tergal and pleural setae on VII, 24–34 (23: 28.4 ± 2.31). Longest seta of medial 10 on tergite VI, 0.075–0.090 (22: 0.084 ± 0.0040); on tergite VII, 0.090–0.120 (23: 0.102 ± 0.0074), with 0–2 (23: 0.6 ± 0.79) of these longer than 0.100. Longer of medial pair of setae on tergite VIII, 0.060–0.085 (22: 0.073 ± 0.0070). Last tergite with 3 lateral setae close together on each side; outer, middle, and inner setae 0.070–0.095 (19: 0.082 ± 0.0067), 0.080–0.105 (20: 0.092 ± 0.0067), and 0.080–0.105 (19: 0.095 ± 0.0057) long, respectively. Abdominal sternal setae: II, 9–13 (23: 10.6 ± 0.84); III, 9–13 (23: 11.5 ± 1.04); IV, 12–17 (22: 14.4 ± 1.50); V, 10–14 (22: 12.0 ± 1.21); VI, 8–13 (22: 10.8 ± 1.60); VII, 6–10 (22: 7.7 ± 1.16). Subgenital plate with 18–23 (23: 21.2 ± 1.53) setae, with distribution and lengths as in Fig. 1, with 1 seta on each side distinctly longer and thicker than others. TL 1.165–1.410 (21: 1.271 ± 0.0525). Postvulval sclerite as in Fig. 1, with 2 subequal short setae posterior to it on each side. Genital sac as in Fig. 4, width (GSW) 0.200–0.280 (17: 0.248 ± 0.0195), length (GSL) 0.100–0.180 (17: 0.132 ± 0.0251); with weak anterior papillose area and with 0–5 (17: 2.1 ± 1.82) transverse anterior lines, posteriormost line, when present, situated 0.020–0.060 (12: 0.042 ± 0.0121) back from anterior sac margin.

Discussion.—The male of *G. truncatus* is



Figs. 1–6. *Geomydoecus truncatus.* 1, Female dorsal (left)—ventral (right) view. 2, Female dorsal left temple margin. 3, Male dorsal left temple margin. 4, Female genital sac. 5, Male ventral genitalia. 6, Male dorsal (left)—ventral (right) view. Measurements are in millimeters.

easily distinguished from all other *Geomydoecus* by its uniquely shaped parameral arch; no other described species of this genus has the distinctive medioposterior flattening. The female is not as readily differentiated, but the combination of the genital sac structure, dimensions, and chaetotaxy features should separate it.

Werneck (1950) described *G. truncatus* from a series of six males taken off *Geomys personatus* from Padre Island, Texas. This locality would make the host *G. p. personatus,* the only pocket gopher that Hall (1981) lists from there. However, we have found only *Geomydoecus texanus texanus* Ewing on that host. The paucity of our records cannot rule out the possibility that *G. truncatus* may also occur there, but, conversely, we are unable to confirm that it does. Our inability to do this becomes critical since we have now determined that what has been known as *G. truncatus* actually consists of two species—one from *Geomys p. streckeri* Davis and the other from *G. p. fallax* Merriam. Price and Emerson (1971) had specimens only from *G. p. streckeri* and named them *Geomydoecus truncatus.* Numerous subsequent collections from *Geomys p. fallax* and the determination that these were different from the *G. p. streckeri* lice raised the necessity of establishing which is the true *Geomydoecus truncatus.* Fortunately, we have been able to examine two of Werneck's paratypes and have determined that they are conspecific with our series from *Geomys p. fallax.*

*Geomys p. fallax* also has *Geomydoecus texanus texanus* occurring on it. Of the six gophers of this host taxon that yielded *G. t. texanus,* only one also had *G. truncatus.* This one gopher had 12 *G. truncatus* and only one specimen of *G. t. texanus,* raising the possibility that the latter might have been a contaminant or straggler. It appears that these two louse taxa, although found on the same host subspecies, occur in exclusive ranges.

Material examined.—2 ♂, Paratypes of *Geomydoecus truncatus,* ex *Geomys personatus,* Padre Island, Texas; 53 ♀, 57 ♂, ex *G. p. fallax,* 9 gophers from 7 localities in San Patricio Co., Nueces Co., and Live Oak Co., Texas.

### *Geomydoecus neotruncatus* Hellenthal and Price, New Species

*Type host: Geomys personatus streckeri* Davis.

Male.—Much as for *G. truncatus,* except as follows. TW 0.405–0.430 (20: 0.420 ± 0.0053); HL 0.310–0.345 (20: 0.326 ± 0.0077). Antennal SL 0.165–0.185 (19: 0.177 ± 0.0051), SMW 0.100–0.120 (19: 0.109 ± 0.0058), SDW 0.100–0.120 (19: 0.112 ± 0.0047). PW 0.305–0.335 (20: 0.309 ± 0.0078). Setae on sternite II, 7–11 (20: 9.1 ± 1.02); VI, 8–12 (19: 9.5 ± 0.90). Genitalia PAW 0.140–0.155 (20: 0.145 ± 0.0048).

Female.—Much as for *G. truncatus,* except as follows. TW 0.440–0.465 (20: 0.448 ± 0.0077); HL 0.300–0.330 (20: 0.316 ± 0.0075); inner marginal temple seta 0.035–0.045 (20: 0.037 ± 0.0030) long. PW 0.325–0.340 (20: 0.329 ± 0.0061). Tergal setae: II, 13–17 (20: 15.0 ± 1.23); III, 18–23 (20: 21.0 ± 1.49); IV, 20–28 (20: 23.9 ± 1.65); V, 20–26 (20: 24.2 ± 1.65). Longer seta of medial pair on tergite VIII, 0.050–0.075 (19: 0.062 ± 0.0068). Outer seta on last tergite 0.060–0.085 (20: 0.075 ± 0.0057) long. Sternal setae: II, 8–11 (20: 9.7 ± 0.91); V, 10–15 (20: 13.0 ± 1.10); VI, 9–14 (20: 12.3 ± 1.22); VII, 8–11 (20: 9.6 ± 0.88).

Discussion.—Both sexes of *G. neotruncatus* are smaller than *G. truncatus* and tend to have fewer abdominal tergal setae and more sternal setae on the posterior segments. For males, the critical values for discrimination and probabilities of misidentification for the best discriminating quantitative characters separating these two taxa are the temple width 0.435 (0.034), prothorax width 0.320 (0.085), and scape length 0.184 (0.109). For females, the best are temple width 0.466 (0.009), prothorax width 0.343 (0.081), and setae on sternite VII 8.69 (0.177).

The males of both species key to *G. truncatus* in the first half of couplet 6 in Timm and Price (1980), where *G. neotruncatus* can be separated by its temple width less than 0.435 and prothorax width less than 0.320. The females of both species key either to *G. truncatus* in couplet 2 or *G. quadridentatus* Price and Emerson in couplet 9. Temple width under 0.466 and prothorax width under 0.343 will distinguish *G. neotruncatus* from *G. truncatus*; both may be separated from *G. quadridentatus* by their shorter setae on pleurites III–IV (Fig. 1 vs. Fig. 7) and differences in the genital sac configuration (Fig. 4 vs. Fig. 8).

Material examined.—Holotype ♀, ex *Geomys personatus streckeri,* 14 mi (22.5 km) W Crystal City, Zavala Co., Texas, 9.II.1953, KU-52238; in collection of the University of Kansas. Paratypes, ex *G. p. streckeri:* ♀, 7 ♂, same as holotype; 22 ♀, 17 ♂, same except KU-52239 or 10.II.1953, KU-52245, 52246; 13 ♀, 11 ♂, E Carrizo Springs, Dimmit Co., Texas, 4.I.1970, TT-9665, 9666; 6 ♀, 4 ♂, 13 mi (20.9 km) N or NE Carrizo Springs, Dimmit Co., Texas, 17.I.1970, TT-10126, 10131; 1 ♀, 1 mi (1.6 km) SW Carrizo Springs, Dimmit Co., Texas, 23.V.1974, TAM-27613; 5 ♀, 4 ♂, Carrizo Springs, Dimmit Co., Texas, 24.XI.1938, TAM-789; paratypes distributed among the United States National Museum of Natural History, Field Museum of Natural History, University of Minnesota, and Oklahoma State University.

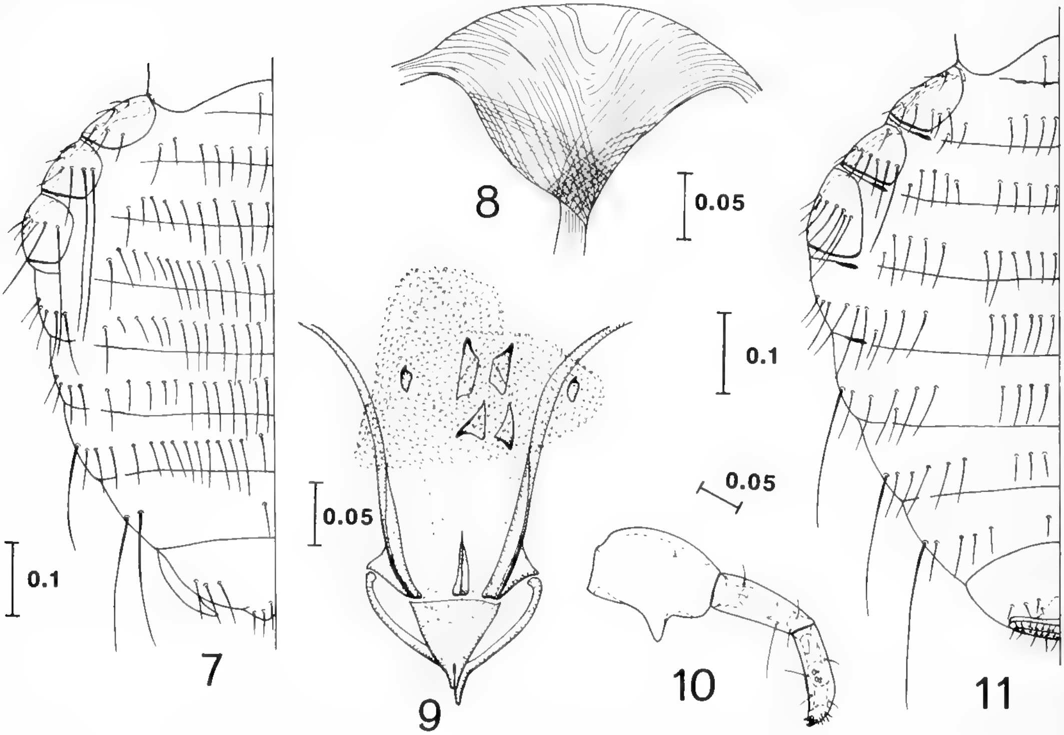
### *Geomydoecus quadridentatus* Price and Emerson

Figs. 7–11

*Geomydoecus quadridentatus* Price and Emerson, 1971: 240. Type host: *Geomys arenarius arenarius* Merriam.

Male.—Grossly as in Fig. 6, except antenna as in Fig. 10, and dorsal abdomen as in Fig. 11. TW 0.365–0.410 (80: 0.392 ± 0.0100); HL 0.270–0.325 (79: 0.295 ± 0.0126); submarginal and inner marginal temple setae 0.040–0.065 (73: 0.052 ± 0.0051) and 0.020–0.030 (79: 0.024 ± 0.0023) long, respectively. Antenna with SL 0.145–0.175 (80: 0.164 ± 0.0069), SMW 0.095–0.120 (80: 0.109 ± 0.0062), SDW 0.115–0.150 (80: 0.135 ± 0.0082); with prominent process on posterior margin (Fig. 10). PW 0.265–0.315 (79: 0.289 ± 0.0112). Abdominal tergal setae: I, 2; II, 8–16 (80: 12.2 ± 1.43); III, 14–23 (78: 18.7 ± 1.65); IV, 17–27 (78: 21.1 ± 2.03); V, 16–26 (78: 19.5 ± 1.90); VI, 11–19 (78: 15.0 ± 1.54); tergal and pleural setae on VII, 15–24 (80: 20.2 ± 1.69). Abdominal sternal setae: II, 9–15 (79: 11.7 ± 1.49); III, 11–17 (79: 13.9 ± 1.39); IV, 11–19 (80: 14.3 ± 1.62); V, 8–14 (80: 10.8 ± 1.42); VI, 6–11 (79: 9.2 ± 1.13); VII, 5–9 (77: 7.3 ± 0.91); VIII, 5–7 (79: 5.9 ± 0.51). TL 1.130–1.415 (79: 1.245 ± 0.0634). Genitalia as in Fig. 9; spinose sac with 4 large central and 0–2 smaller laterally displaced spines; parameral arch with prominent medioposterior projection, PAW 0.130–0.155 (79: 0.144 ± 0.0052); endomeral plate triangular with short apical division, EPW 0.065–0.080 (80: 0.072 ± 0.0035), EPL 0.060–0.080 (80: 0.071 ± 0.0049).

Female.—Grossly as in Fig. 1, except dorsal abdomen as in Fig. 7. TW 0.400–0.470 (80: 0.439 ± 0.0122); HL 0.260–0.310 (80: 0.283 ± 0.0098); submarginal and inner marginal temple setae 0.040–0.070 (78: 0.054 ± 0.0051) and 0.040–0.050 (78: 0.045 ± 0.0036) long, respectively. PW 0.280–0.345 (80: 0.311 ± 0.0120). Abdominal tergal setae: I, 2; II, 13–19 (78: 15.2 ± 1.40); III, 19–27 (77: 21.8 ± 1.94); IV, 20–30 (77: 24.6 ± 2.40); V, 18–28 (78: 22.5 ± 2.21); VI, 16–26 (79: 20.9 ± 2.38); tergal and pleural setae on VII, 25–39 (80: 32.4 ± 2.95). Longest seta of medial 10 on tergite VI, 0.070–0.100 (80: 0.087 ± 0.0062); on tergite VII, 0.085–0.115 (80: 0.102 ± 0.0069), with 0–6 (80: 0.9 ± 1.44) of these longer



Figs. 7–11. *Geomydoecus quadridentatus.* 7, Female dorsal abdomen. 8, Female genital sac. 9, Male ventral genitalia. 10, Male ventral antenna. 11, Male dorsal abdomen. Measurements are in millimeters.

than 0.100. Longer of medial pair of setae on tergite VIII, 0.050–0.085 (79: 0.067 ± 0.0082). Last tergite with outer, middle, and inner setae 0.045–0.075 (74: 0.058 ± 0.0064), 0.060–0.090 (74: 0.074 ± 0.0065), and 0.060–0.090 (79: 0.076 ± 0.0069) long, respectively. Abdominal sternal setae: II, 8–16 (79: 11.9 ± 1.77); III, 11–17 (77: 14.3 ± 1.26); IV, 11–19 (79: 15.0 ± 1.75); V, 8–16 (78: 11.8 ± 1.51); VI, 7–12 (78: 9.6 ± 1.02); VII, 6–11 (78: 8.8 ± 0.96). Subgenital plate with 18–26 (80: 21.7 ± 2.07) setae. TL 1.090–1.335 (79: 1.198 ± 0.0532). Genital sac as in Fig. 8, GSW 0.175–0.255 (79: 0.206 ± 0.0144), GSL 0.155–0.200 (77: 0.181 ± 0.0115), with 0–4 (79: 2.1 ± 0.82) curved medioanterior loops, posteriormost loop, when present, situated 0.040–0.105 (78: 0.071 ± 0.0115) back from anterior sac margin.

Discussion.—Both sexes of *G. quadridentatus* are easily separated from *G. truncatus* and *G. neotruncatus.* Males of *G. quadridentatus* have conspicuously different genitalia (Fig. 9 vs. Fig. 5), the antennal scape with a posterior process (Fig. 10), and dorsal abdominal chaetotaxy (Fig. 11) with longer setae on pleuron V, generally longer lateral tergal setae, and the three short setae on each side of the last tergite evenly spaced and aligned with very short seta as shown. Females of *G. quadridentatus* have a different line configuration of the genital sac (Fig. 8 vs. Fig. 4) and longer pleural setae at least on abdominal segments III–V (Fig. 7). These three species of lice also are well separated geographically, with *G. quadridentatus* distributed in north central Chihuahua, western Texas, and south central New Mexico, and with *G. truncatus* and *G. neotruncatus* in south central Texas (Fig. 12).

As originally described by Price and Emerson (1971), males of *G. quadridentatus* were said to have only four large genital sac spines, with no mention of one or two smaller laterally displaced spines. However, recent examination of much larger series of lice than were available earlier has shown 94 of 179 (52.5%) males with only the four large central spines, 46 (25.7%) with a single smaller additional spine, and 39 (21.8%) with two smaller spines as in Fig. 9. The percentage of gophers with no, one, or two smaller sac spines is essentially the same for all gopher populations of *G. quadridentatus* studied. The presence of these smaller spines should not complicate proper identification, if other characters and host association are considered.

There is discussion among mammalogists as to whether *Geomys arenarius* is a valid species apart from *G. bursarius* (Shaw). Also uncertain are the relationships among up to five populations of *Geomys* possessing what we here call *Geomydoecus quadridentatus:* 1) gophers around Gran Quivera, New Mexico; 2) gophers around San Antonio, New Mexico; 3) gophers considered to be *G. a. brevirostris* Hall; 4) a "river" population of gophers belonging to *G. a. arenarius*; and 5) an "upland" population of *G. a. arenarius.* We collected numerous lice from all five of these groups, analyzed them qualitatively and quantitatively, and could find no meaningful differences. We could demonstrate occasional quantatitive character differences at a relatively high probability of misidentification, but these showed no consistent occurrence. We do not believe these louse populations merit taxonomic distinctions at this time. Speaking strictly from the louse standpoint, the lice from all five populations are sufficiently different from lice from *Geomys bursarius* to support *G. arenarius* as a separate taxon and sufficiently similar to each other to group all five gopher populations into *G. arenarius.*

Material examined.—244 ♀, 267 ♂, ex *Geomys arenarius arenarius,* 50 gophers from 17 localities in New Mexico, Texas, and Chihuahua; 67 ♀, 51 ♂, ex *G. a. brevirostris,* 15 gophers from 6 localities in New Mexico; 26 ♀, 22 ♂, ex *Geomys,* 7 gophers from 2 localities near Gran Quivera, New Mexico; 35 ♀, 28 ♂ ex *Geomys,* 4 gophers near San Antonio, New Mexico.

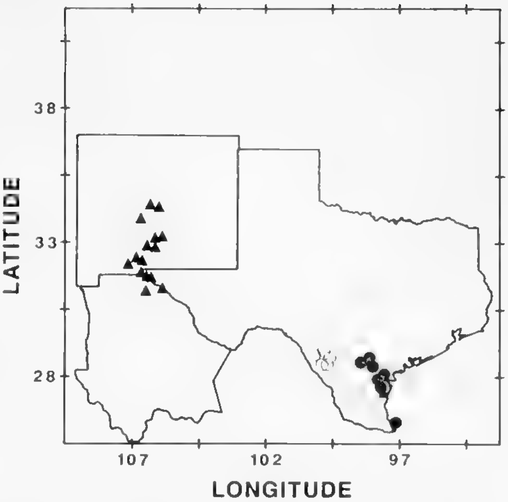


Fig. 12. Geographic distribution of *Geomydoecus truncatus* (closed circles), *G. neotruncatus* (open circles), and *G. quadridentatus* (triangles).

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# BIOLOGICAL AND MORPHOLOGICAL ASPECTS OF THE EGG STAGE AND OVIPOSITION OF *LANGURIA MOZARDI* (COLEOPTERA: LANGURIIDAE)

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*Abstract.*—Oviposition sites of *Languria mozardi* Latreille, the clover stem borer, were determined on *Trifolium incarnatum* L., a previously unreported host. The 2nd and 3rd internodes of primary flowering stems are the preferred sites on *T. incarnatum.* Oviposition occurs in stems of *T. repens* L., *T. pratense* L., *T. hybridum* L., *T. resupinatum* L., *T. striatum* L., *T. nigrescens* Viv., and *T. subterraneum* L. but not on *T. lappaceum* L.. There is usually one oviposition puncture and egg per stem, the egg being attached to the plant tissue by an extension on the posterior end. The micropylar region is simple in form and the chorionic surface has a granular appearance. The sensilla on the ovipositor differ in the types, number, and distribution as compared to the sensilla on the ovipositor of other beetle species. The ablation experiment indicates that these sensilla on the ovipositor are possibly involved in selecting a suitable oviposition site.

*Key Words:* *Languria mozardi,* sensilla, larva, mouth parts, antenna

The clover stem borer, *Languria mozardi* Latreille, is endemic to North America on a wide range of host plants including the Leguminosae, Compositae, Umbelliferae, and Gramineae. It is considered a pest of alfalfa, *Medicago sativa* L., and red clover, *Trifolium pratense* L. (Lintner 1881, Folsom 1909). Wildermuth and Gates (1920) reported early studies on the biology, morphology, and pest status of *L. mozardi* on forage crops. Damage from larval feeding inside stems weakens the plant and results in lodging, loss of seed, and forage production. Damage to stems also may predispose plants to root rot pathogens. Increased fiber content in damaged stems reduces forage quality (Wildermuth and Gates 1920).

Except for a single report (Knight et al. 1976) from arrowleaf clover, *T. vesiculosum* Savi, *L. mozardi* is known as a forage pest only on perennial legumes. This insect has been collected annually in Mississippi from 1982–85 on *T. vesiculosum, T. incarnatum* L. (crimson clover) and from 1983–85 on *T. alexandrinum* L. (berseem clover). The importance of seed production in annual clovers to ensure stand persistence and the ability of *L. mozardi* to reduce seed and forage yield in other legumes makes this insect a potential pest of annual clovers.

No information is available on the biology of *L. mozardi* on annual clovers and existing morphological studies are incomplete. In the present study, oviposition sites and frequencies on crimson clover, a previously unreported host, are reported from greenhouse studies. Host range for oviposition also are determined on several clover species that are or have been of economic importance. The morphology of the egg and ovipositor sensilla are described.

## Materials and Methods

Adult *L. mozardi* were collected from roadside plantings of crimson clover using a motorcycle-mounted collection net (Ellsbury and Davis 1982). Pairs of mating *L. mozardi* were sorted from collections, provided with a water source, and held 24 h in a 9-cm diam plastic Petri dish. To determine oviposition sites on crimson clover, 3 pairs of insects were confined for 24 h on each of 12 greenhouse-grown flowering crimson clover plants in cylindrical screened cages (14-cm diam × 90 cm). Host range for oviposition by *L. mozardi* on other *Trifolium* species also was studied by similarly caging 3 pairs of insects on each of 2 greenhouse-grown flowering plants of *T. repens* L. (white clover), *T. pratense* (red clover), *T. hybridum* L. (alsike clover), *T. resupinatum* L. (persian clover), *T. striatum* L. (pitts or striate clover), *T. nigrescens* Viv. (ball clover), *T. lappaceum* L. (lappa clover), and *T. subterraneum* L. (subterranean clover). After 24 h exposure to test insects, stems were split using a single-edge razor blade and the location and number of eggs were recorded for oviposition punctures on primary and lateral stems.

An average internodal location of oviposition punctures was calculated for clovers in the host range study from integer values assigned to each internode beginning with the lowermost internode (#1) and increasing to the (last) internode below the flower head of each stem.

Eggs were removed from the clover stems and placed in 5% glutaraldehyde in 0.1 M Na-cacodylate buffer at pH 7.2 for 12 h at 4°C. The specimens were washed in the same buffer and then post-fixed in 4% $OsO_4$ in cacodylate buffer for 8 h. After dehydration the eggs were critical-point dried, affixed to aluminum stubs with tape, sputter coated with Au/Pd, and examined with a Hitachi HHS-2R scanning electron microscope at 20 kV. The same preparation procedure was used for the ovipositors. Measurements were made with a light microscope with a calibrated ocular micrometer and are given as a mean plus the range.

Mated females for the behavioral experiments were anesthetized with $CO_2$ and the ovipositor was gently pulled out and treated with 16% HCl. They were placed in petri dishes with a moist filter paper and allowed to recover overnight. Six treated and 6 untreated females were placed in petri dishes containing pieces of flowering clover stems with the second and third internodes. The specimens were examined every 10 minutes for 1 h and the experiment was replicated 3 times.

## Results

Frequency distribution by internode of oviposition sites on crimson clover containing 1 or 2 eggs is illustrated in Fig. 1. Oviposition punctures were most frequent (22/63 and 18/63, respectively) in the 2nd and 3rd internodes of primary flowering stems. No eggs were deposited in lateral flowering stems. Of 78 stems examined, 11 had 2 oviposition punctures and 41 had one puncture. Six of 8 sites where 2 eggs were deposited were situated at the 3rd internode. Mean number of eggs per stem was 0.86 ± 0.11 ($\bar{x} \pm$ SE, N = 78).

Oviposition by *L. mozardi* in 11 species of clovers during a no-choice test is summarized in Table 1. Lappa clover, *T. lappaceum*, was the only species in which eggs were not deposited. The usual number of eggs per site is 1 or 2 for all clovers studied, although 3 eggs occurred in a single puncture on *T. nigrescens* and 4 eggs in a puncture on a stem of *T. pratense*. Eggs were usually deposited in sites at the 3rd internode or higher on all clovers studied. The greatest number of eggs per stem (0.75 ± 0.33) were deposited in red clover, *T. pratense*.

Behavior of the adult female during ovi-

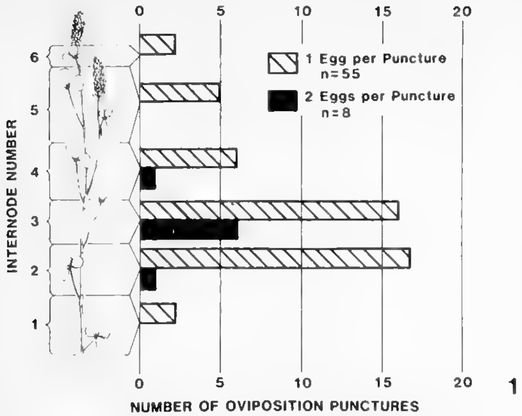

Fig. 1. Internodal frequency distribution of *Languria mozardi* egg punctures containing 1 or 2 eggs in stems of crimson clover, *Trifolium incarnatum*.

position is similar on all *Trifolium* species included in these studies. After chewing a hole in the plant tissue the female uses her ovipositor to excavate a cavity in the pith into which the egg is placed. Externally, the opening is covered by shredded plant material while internally the opening is surrounded by a distinct rim (Fig. 2a, b). The egg is attached to the plant tissue by an extension from the tapered end (Fig. 2c). The egg is clyindrical, translucent yellowish, tapered at one end and measures 1545 μm (1455–1800) in length and 495 μm (480–510) in width (Fig. 2d). The micropyle is situated on the blunt end and consists of a small, irregular shaped area from which several ridges radiate (Fig. 2e). At low magnification the surface of the chorion appears smooth (Fig. 2d) but at higher magnifications the surface has a rough, granular appearance and minute openings are dispersed randomly over the surface (Fig. 2f).

The ovipositor coxites are pointed distally and near the middle of the ventral surface of each coxite there is an area with a high concentration of long, slender spines (Fig. 3a, b). Just posterior to the distal end of each coxite a short style is present (Fig. 3a, b). It is 72 μm (69–74 μm) long and 20 μm (18–21.5 μm) wide and 10 sensilla trichodea are on the apex (Fig. 3b, d). These sensilla vary in length from 23.5 μm (21–25 μm) to 98 μm (95–101 μm) and they are either slightly curved or straight (Fig. 3d). Another group of 9 sensilla trichodea are situated on the ectal surface of each coxite near the base of the style (Fig. 3a, c). These trichoid sensilla range in length from 19 μm (17.5–21 μm) to 71.5 μm (69–74 μm). The 6 sensilla positioned between the straight single posterior and 2 long straight anterior sensilla are slightly curved (Fig. 3c). Sensilla basiconica are situated on the dorsal and

Table 1. Frequency and internodal sites of oviposition by *Languria mozardi* in eleven *Trifolium* species during a no-choice test.

| *Trifolium* Species[1] | No. Stems | Eggs/Stem[2] | Mean No. Nodes/Stem | Ave. Internodal Location of Oviposition Punctures |
|---|---|---|---|---|
| **T. subterraneum* | 19 | .47 ± .16 | 6.42 ± .55 | 4.67 ± .69 |
| *T. lappaceum* | 22 | 0 | 9.14 ± .60 | — |
| **T. nigrescens*[3] | 5 | — | 7.00 ± .32 | — |
| **T. resupinatum* | 26 | .23 ± .08 | 5.65 ± .23 | 4.17 ± .65 |
| **T. repens* | 13 | .38 ± .14 | 7.96 ± 1.04 | 3.40 ± 1.17 |
| **T. striatum* | 16 | .44 ± .18 | 6.25 ± .40 | 3.00 ± .82 |
| *T. pratense* | 12 | .75 ± .33 | 5.25 ± .37 | 5.00 ± .50 |
| *T. vesiculosum* | 16 | .69 ± .24 | 10.50 ± .61 | 8.27 ± .75 |
| **T. alexandrinum* | 13 | .23 ± .12 | 12.85 ± .69 | 7.67 ± 1.45 |
| **T. hybridum* | 9 | .22 ± .18 | 8.22 ± .78 | 4.00 ± 1.00 |
| **T. nicarnatum* | 16 | .69 ± 1.8 | 6.50 ± .33 | 4.22 ± 0.43 |

[1] *Trifolium* species preceded by * are previously unreported hosts.
[2] All numbers are mean ± standard error.
[3] Only one *T. nigrescens* plant used; 3 eggs laid in a single stem.

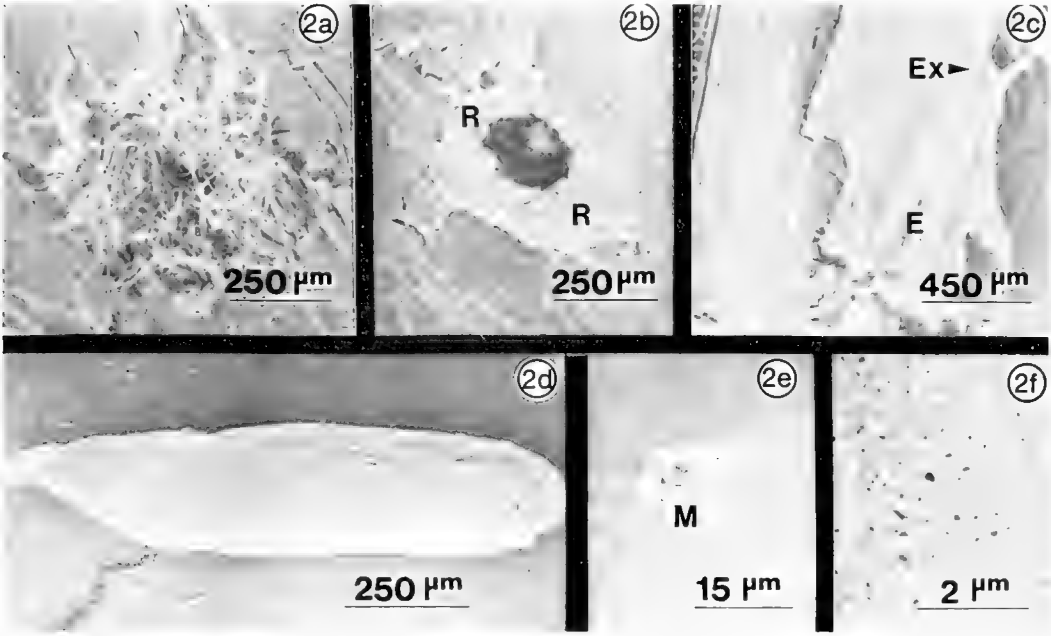

Fig. 2a–f. Egg of *L. mozardi*. a, External appearance of the oviposition site. b, Rim surrounding the oviposition opening internally. c, Tapered end of the egg attached to the plant tissue. d, *L. mozardi* egg. e, Micropylar area. f, Chorion surface. E = egg; Ex = egg extension; M = micropyle; R = rim.

ventral surfaces of the coxites (Fig. 3e). These basiconica sensilla are 5.5 µm (4–6 µm) in length and are situated on a cuticular depression (Fig. 3e). There are pores (ca. 1 µm wide) on both surfaces which are interspersed among the basiconic sensilla (Fig. 3e). The sensilla trichodea and basiconica are stained with the silver nitrate.

In the behavioral experiments, none of the 18 treated females excavated any oviposition sites on the stems or laid any eggs whereas the untreated females made oviposition excavations and deposited eggs. Many of the treated females left the stems after 20 to 30 minutes.

## Discussion

Oviposition behavior of *L. mozardi* in crimson clover is consistent with that reported by Folsom (1909) in red clover and by Wildermuth and Gates (1920) in alfalfa. Eggs are usually laid singly but occasionally 2 or more are deposited in a single puncture. Normally one, and infrequently 2, puncture(s) are found per stem.

The distribution of oviposition sites may be an important consideration in sampling for clover stem borer egg populations in crimson clover. Most oviposition (54/63 sites) occurs in the stem interval between the 2nd and 4th internodes. Sampling time for egg-infested crimson clover stems could be reduced by limiting samples to stem sections including only the 2nd through 4th internodes.

Previously reported hosts of *L. mozardi* in the genus *Trifolium* include only *T. pratense* (Lintner 1881, Folsom 1909) and *T. vesiculosum* (Knight et al. 1976). Since oviposition by *L. mozardi* occurs in 7 additional *Trifolium* species (Table 1) these clovers also should be considered potential hosts for this insect pending confirmation of their suitability as hosts for larval development.

The excavation for oviposition is similar to that described for *L. mozardi* by Girault (1907) but he does not mention the rim surrounding the opening internally. The egg shape of *L. mozardi* differs from *Languria*

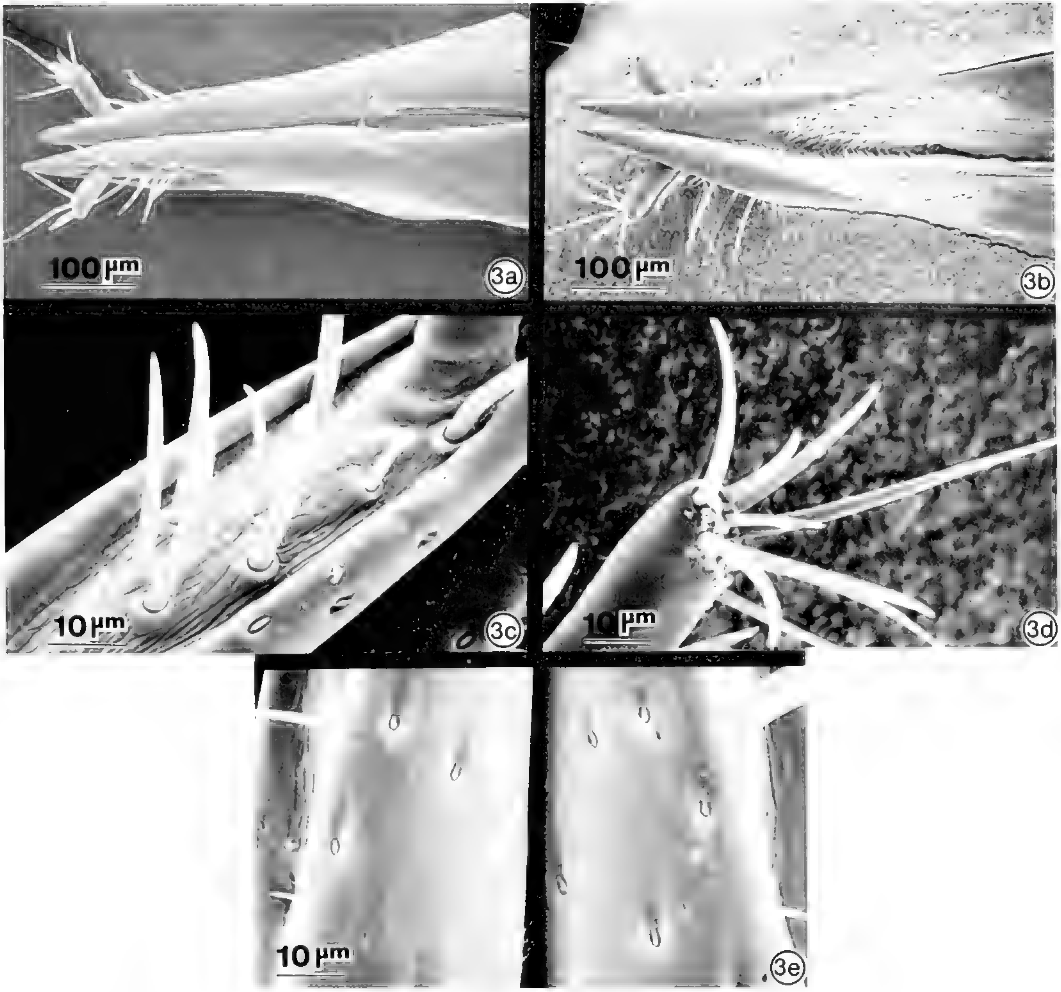

Fig. 3a–e. Ovipositor of *L. mozardi.* a, Dorsal surface. b, Ventral surface. c, Sensilla at the base of the stylus. d, Sensilla on the apex of the stylus. e, Short sensilla basiconica on the dorsal surface.

*erythrocephalus* Blatchley and *Acropteroxys gracilis* (Crotch) in that the end opposite the micropyle is more tapered in *L. mozardi* as compared to a blunt end in the other 2 languriid species (Piper 1978, Genung et al. 1980). The extension from the tapered end of the egg is used to attach the egg to the plant tissue and this structure was not observed in other languriid species but is similar in structure and function to the one found on the egg of *Lyctus brunneus* (Stephens) (Iwata and Nishimoto 1982).

Sensilla are situated on the apex of the styli and near the base of the styli in other beetles such as *Acanthoscelides obtectus* Say (Bruchidae) (Szentesi 1976), *Altica lythri* Aube (Chrysomelidae) (Phillips 1978), and *Thanasimus dubius* (F.) (Cleridae) (Baker and Nebeker 1986). There are differences in the types and numbers of sensilla on the ovipositor of the three previously mentioned species as compared to those on *L. mozardi.* Sensilla chaetica, trichoidea, and basiconica are situated on the apex of the styli and near the base of the styli in *A. obtectus* (Szentesi 1976) and *T. dubius* (Baker and Nebeker 1986) but *L. mozardi* has no sensilla basiconica in this region. The number of sensilla on the apex of the style of *L. mozardi* (9–10) is similar to *A. lythri* (8–11) (Phillips 1978) but differs from *A. obtectus* (22–24) and *T. dubius* (23–25) (Szentesi 1976, Baker and Nebeker 1986). The short basiconic sensilla which are situated on the dorsal and ventral surfaces of the ovipositor of *L. mozardi* are lacking on the ovipositors of the other three beetle species.

The behavioral experiment indicates that the sensilla on the ovipositor of *L. mozardi* are needed for the deposition of an egg in the plant substrate. Sensilla on the ovipositor of other insects are known to respond to chemicals such as salts, water, and amino acids (Rice 1976, 1977, Chadha and Roome 1980, Hood-Henderson 1982, Liscia et al. 1982). The sensilla trichoidea and basiconica on the ovipositor of *L. mozardi* may respond to chemicals in the clover plant which are released during the excavation of an oviposition site.

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# MORPHOLOGY OF THE MOUTH PARTS AND ANTENNA OF THE LARVA OF THE CLOVER STEM BORER, *LANGURIA MOZARDI* LATREILLE (COLEOPTERA: LANGURIIDAE)

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*Abstract.*—The morphology of the mouth parts and antennae, including the sensilla on these structures, is described. The mouth parts have several types of sensilla (basiconica, digitiformia, chaetica, trichoidea, campaniformia, and coronal pegs). The apex of each labial (10 sensilla) and maxillary (11 sensilla) palpus has the highest number of sensilla. The striated region on each mandible is composed of several striae and each of these has several rows of blunt, stout pegs. The antennae possess trichoid, basiconic, campaniform, and placoid sensilla and an antennal sensory appendix which is situated on segment 2.

*Key Words:* Languriidae, *Languria mozardi,* larva, mouth parts, antennae, sensilla

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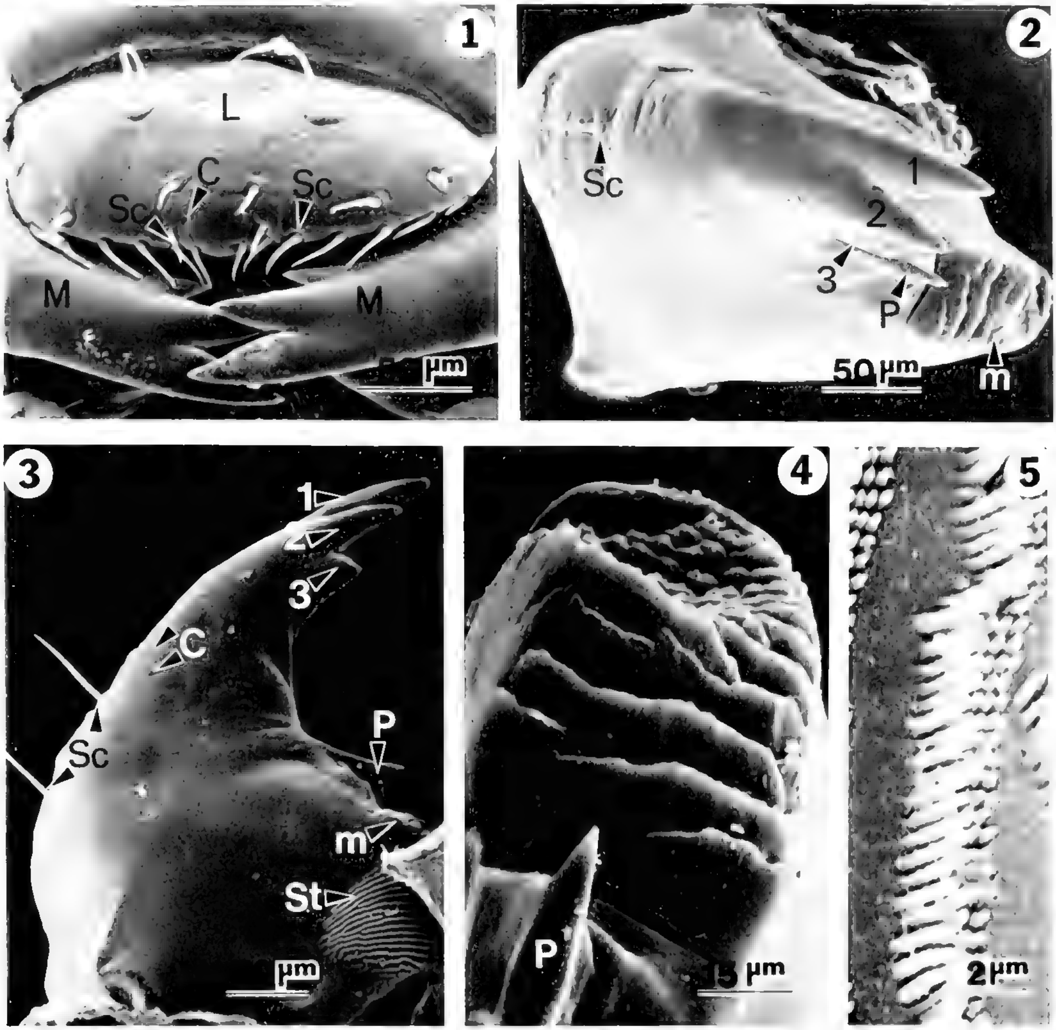
The clover stem borer, *Languria mozardi* Latreille, is nearly ubiquitous in North America on a wide range of cultivated and wild host plants (Wildermuth and Gates 1920). Adults occur frequently in the annual clovers *Trifolium incarnatum* L. (crimson clover), *T. vesiculosum* Savi (arrowleaf clover), and *T. alexandrinum* L. (berseem clover), grown for forage, soil stabilization, and as cover crops in the Southeast.

The clover stem borer causes lodging, reduced seed set and poor forage quality as a result of removal of stem tissue, loss of foliage under stress, and increased fiber content (Wildermuth and Gates 1920). The impact of *L. mozardi* on forage production has probably been underestimated because of the seclusive nature of the adults and the cryptic habits of the larvae. The insect is likely to be of economic importance where clovers are grown for hay or seed production.

Wildermuth and Gates (1920) recommended cultural control through crop rotation, early cutting for hay production, and sanitation of field margins to reduce overwintering populations. Selection and breeding of clovers for stem characteristics to reduce establishment and survival of the larva would be an alternative control method. The present studies were initiated to describe the morphology, distribution, and number of sensory receptors on larval mouth parts and antennae of *L. mozardi* that may mediate feeding or tunneling activity of the larva through contact with the host plant.

## MATERIALS AND METHODS

Specimens of final (5th) instar larvae of *L. mozardi* were reared on artificial diet (Rose and McCabe 1973). Use of the diet permitted verification of molting to ensure that 5th instar larvae were examined. The techniques for SEM and staining the specimens are given in Baker et al. (1986). All SEM observations are based on 8 last (5th) instar larvae.

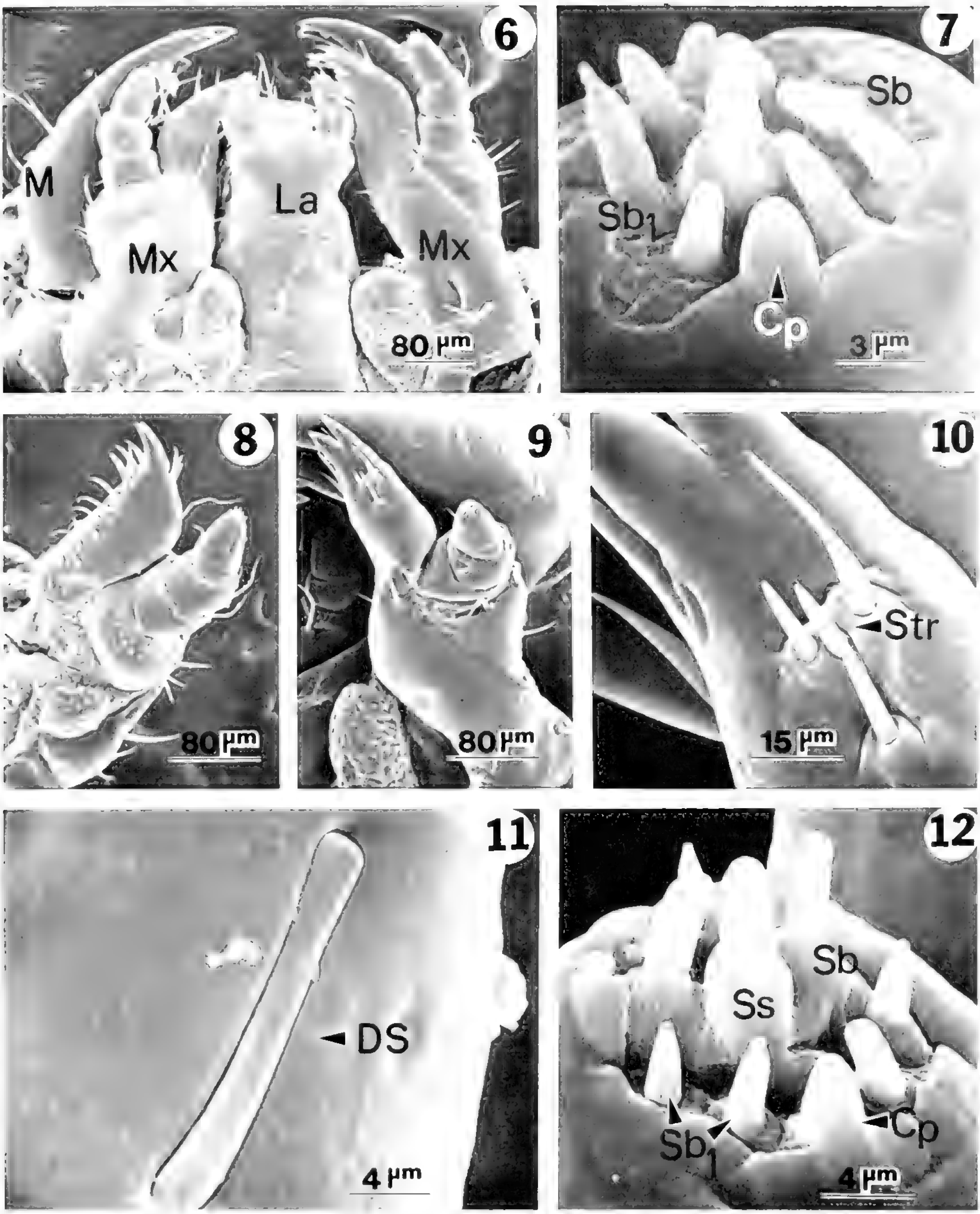


Figs. 1–5. Labrum and mandibles of *L. mozardi*. 1. Distal row of sensilla chaetica on the labrum that extend to the mandibles. 2. Mandible, apical view. 3. Mandible, ectal surface. 4. Molar region. 5. Stria composed of several rows of stout, conical setae. C = campaniform sensillum; L = labrum; M = mandible; m = mola; P = prostheca; Sc = sensillum chaeticum; St = stria; 1, 2, 3 = mandibular dentes.

## RESULTS

The broad, rounded labrum has 24 sensilla chaetica that are mostly situated on the posterior edge of the labrum where they come in contact with the mandibles (Fig. 1). Just above these sensilla, there are 2 campaniform sensilla that are situated near the mid-line of the labrum.

The mandibles have a tridentate apex, a distinct mola, a small and pointed prostheca and a striated region near the mola (Figs. 2, 3, 4). The 2 apical teeth are similar in size while the basal tooth is smaller. A prostheca is distad of the mola which is deeply grooved and the grooves increase in density from the basal to the distal region of the mola. Laterad of the mola is a striated region (at low magnifications) but each stria (at high magnifications) is composed of several rows of blunt, stout spines (Figs. 3, 5). Two sensilla chaetica and several campaniform sensilla are situated on the ectal surface of the mandibles (Fig. 3).



Figs. 6–12. Labial and maxillary regions of the mouth parts. 6. Labium, maxillae, and mandibles. 7. Labial palpus, apex. 8. Maxilla, inner surface. 9. Maxilla, outer surface. 10. Sensilla trichodea at base of maxillary dentes. 11. Digitiform sensillum. 12. Sensilla on apex of maxillary palpus. Cp = coronal peg; DS = digitiform sensillum; La = labium; M = mandible; Mx = maxilla; Sb = sensillum basiconicum (blunt); $Sb_1$ = sensillum basiconicum (tapered); Ss = sensillum styloconicum; Str = sensillum trichodeum.

There is a total of 8 trichoid sensilla on the ligula, mentum, and submentum of the labium (Fig. 6). The labial palpi are 2-segmented and the 2nd segment is longer. At the apex of segment 2 there are 10 sensilla (Fig. 7). The central sensory receptor is a styloconic sensillum which has a short base with a long peg (Fig. 7). There are 8 sensilla basiconica, 7 that are blunt and one that has a tapered tip (Fig. 7). These sensilla are located on the periphery of the terminal palpal segment. There is also one dome shaped sensillum that is situated on a cuticular protrusion (Fig. 7). This sensillum is known as a coronal peg (Doane and Klingler 1978).

The maxilla is well developed with a 3-segmented palpus and a mala which is long and curved with 2 large dentes at the apex (Figs. 8, 9). Just below the dentes there is a row of large sensilla chaetica on the inner surface of the mala (Fig. 8), and on the outer surface, 4 sensilla trichoidea are located at the base of the dentes (Figs. 9, 10).

The maxillary palpi are 3-segmented and the 3rd is the longest. There are 2 sensilla chaetica on each palpal segment and 11 sensilla are situated on the apex of segment 3 (Figs. 8, 9, 12). These sensilla are similar to those on the apex of the labial palpus but there are more tapered basiconic sensilla on the maxillary palpus (Fig. 12). A single digitiform sensillum is located on the inner surface of the last palpal segment (Fig. 11). The stipe and cardo are asperate (Fig. 8). There are 2 pouch-like structures that are situated between the submentum of the labium and the cardo of each maxilla (Fig. 6). These structures are also asperate.

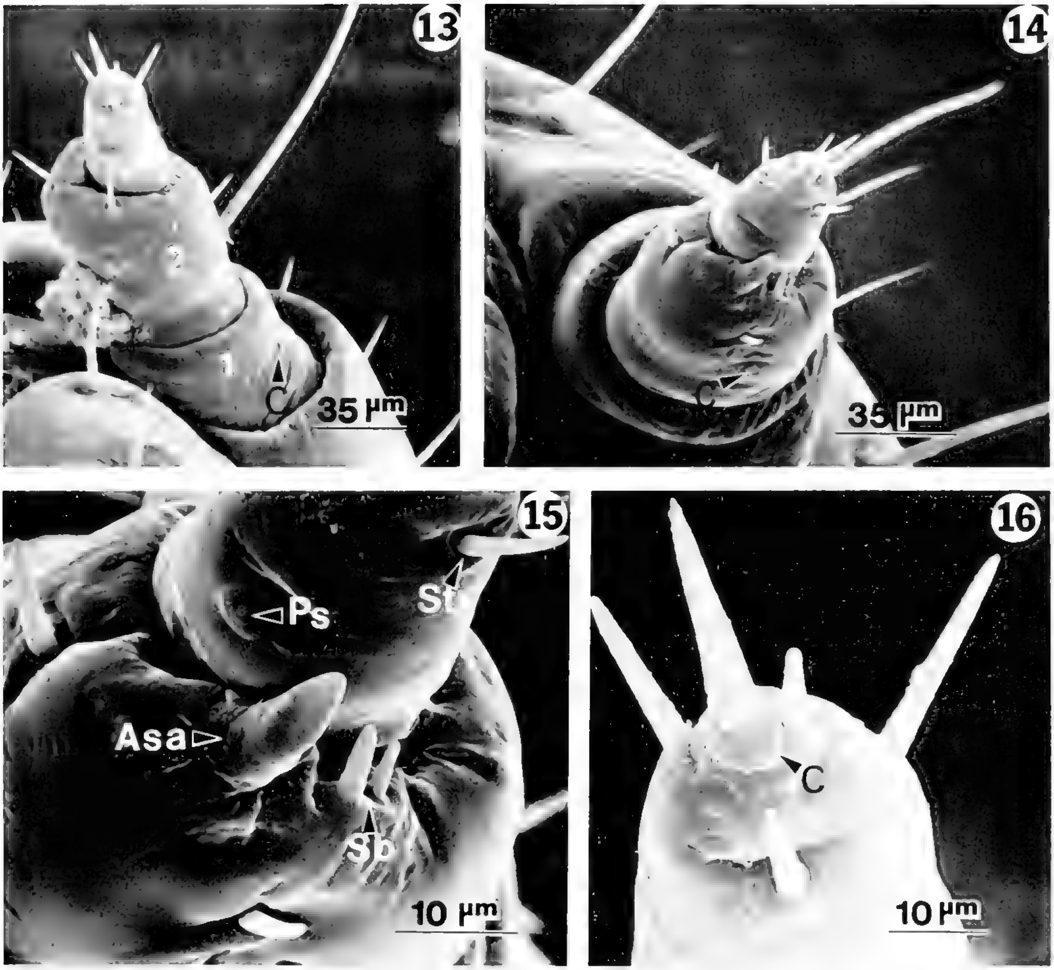
There are 3 antennal segments and segment 2 is the longest (Fig. 13). Segment 1 is devoid of any hair-like sensory structures but there are 4 campaniform sensilla (Figs. 13, 14). On the apical periphery of segment 2 there are 5 blunt trichoid sensilla (Figs. 14, 15). A single, long sensillum chaeticum is situated on the outer, lateral surface of subsegment 2 (Fig. 13). The antennal sensory appendix is on the ventral side of segment 2 near the intersegmental membrane between segments 2 and 3 (Fig. 15). Laterad of this sensillum there are 2 sensilla basiconica (Fig. 15).

Segment 3 has a raised area at the apex on which are situated 3 sensilla, a campaniform sensillum, and a trichoid and basiconic peg (Fig. 16). Just proximal of these receptors are 3 trichoid sensilla (Fig. 16). A placoid sensillum is situated on the ventral surface of segment 3 near the antennal sensory appendix (Fig. 15). Only the sensilla chaetica and campaniformia that are situated on the mouth parts and antennae do not stain with crystal violet or reduced silver, thus indicating their nonporosity. All other sensilla that are mentioned pick up these stains indicating that these sensilla have a porous cuticular peg.

## DISCUSSION

The close proximity of the labral sensilla chaetica to the underlying mandibles indicates that these sensilla probably act in monitoring the position of the labrum and mandibles during feeding. Campaniform sensilla are known to act as stress receptors and the 2 sensilla situated on the middle portion of the labrum may function as cuticular stress receptors.

In previous descriptions of larval languriid mandibles (Comstock and Comstock 1916, Peterson 1951) there is no mention of the structure of the molar surface and the striae that occur laterad the mola. The deeply grooved molar surface aids in grinding plant material that is to be ingested. Several rows of blunt spines comprise each of the striae that are present on the mandibles. They are also present on the same region of *Tribolium* larvae (Kvenborg 1977). The function of the striae is unknown, but they could be involved in stridulation or grooming. The 2 nonporous sensilla chaetica and several campaniform sensilla on the ectal surface of each mandible probably function as those located on the labrum, to monitor



Figs. 13–16. Larval antenna of *L. mozardi*. 13. Antenna, dorsal surface. 14. Antenna, ventral surface. 15. Intersegmental region between antennal segments 2 and 3. 16. Antenna, apex. Asa – antennal sensory appendix; C = campaniform sensillum; Ps = placoid sensillum; Sb = sensillum basiconicum; Str = sensillum trichodeum.

cuticular stress and to relay information on the position of the mouth parts in relation to one another.

The general structure of the labium is similar to the descriptions for other languriid species (Wildermuth and Gates 1920, Piper 1978). *L. mozardi* differs from *Acropteroxys gracilis* (Newman) in the number and types of sensilla situated on the apex of the labial palpi. *A. gracilis* has 11–12 basiconic sensilla on the apex of the palpus (Piper 1978), while *L. mozardi* has a total of 9–10 sensilla but there are 2 types of basiconic sensilla, a sensillum styloconicum and a coronal peg.

A similar situation exists when one compares the number and types of sensilla on the maxillary palpal apex of *L. mozardi* and *A. gracilis*. *L. mozardi* has 10–11 sensilla, 1 styloconic and coronal sensillum and 2 types of basiconic sensilla while *A. gracilis* has 11–12 basiconic sensilla. The total number of apical sensilla on the maxillary (11) and labial (10) palpi of *L. mozardi* is similar to what is found on *Tribolium* larvae (13 & 12) (Ryan and Behan 1973) and

*Hypera* larvae (12 & 11) (Bland, 1983). But the various types of apical sensilla on these structures of *L. mozardi* resemble the apical sensilla on wireworm larvae (Doane and Klingler 1978).

The maxillary and labial apical basiconic and styloconic sensilla stain with crystal violet and reduced silver indicating that these sensilla have a porous cuticle. Also, behavioral and electrophysiological studies on other coleopterous larvae have shown that similar receptors respond to $CO_2$ and other chemicals and therefore may be considered to be chemoreceptors (Klingler 1966, White et al. 1974, Doane and Klingler 1978, Mitchell 1978).

The external structure of the digitiform sensillum is similar to what is found on other coleopterous larvae (Zacharuk et al. 1977, Doane and Klingler 1978, Guse and Honomichl 1980, Honomichl 1980). Ultrastructural and electrophysiological evidence indicate that this sensillum is a type of mechanoreceptor that is involved in monitoring the larva's tunneling activity (Zacharuck et al. 1977).

The total number of antennal sensilla on *L. mozardi* (22) is similar to *Tenebrio molitor* L. (24 sensilla) (Pierantoni 1969) and *Tribolium* larvae (21 sensilla) (Behan and Ryan 1978). The morphology of the basiconic and porous trichoid sensilla resembles that found on other coleopterous larvae, and ultrastructural studies indicate that these sensilla are chemoreceptors (Behan and Ryan 1978, Bloom et al. 1982a, b). The antennal sensory appendix of *L. mozardi* is similar in morphology and position on the antenna as that on elaterid larvae (Zacharuk 1962). The fine structure of the sensory appendix suggests that it functions as an olfactory receptor (Scott and Zacharuk 1971). The ultrastructure of the placoid sensillum on tenebrionid larvae indicates a chemosensory function (Behan and Ryan 1978, Bloom et al. 1982), but electrophysiological data is lacking.

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# NORTH AMERICAN MOTHS DESCRIBED BY L. A. G. BOSC D'ANTIC (LEPIDOPTERA: NOCTUIDAE, PYRALIDAE)

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*Abstract.*—Three species of moths were described from "Caroline" by Bosc [1800]. *Crambus adspergillus* Bosc was recognized by Franclemont and Todd (1983) as *Renia adspergillus* (Noctuidae), but the other two names have remained unplaced. We recognize *Alucita cereella* Bosc as conspecific with *Nola sorghiella* Riley, n. syn. (Noctuidae) and *Pyralis sacculana* Bosc as conspecific with *Clydonopteron tecomae* Riley, n. syn. (Pyralidae).

*Key Words:* nomenclature, Nearctic, moths, Noctuidae, Pyralidae

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The frenchman Louis Auguste Guillaume Bosc d'Antic (1759–1828) lived in the United States during the French Revolution and collected insects, especially in South Carolina (Blake 1952; Zimsen 1964: 16–17). His collection, which contained many type specimens including several of those described by J. C. Fabricius, went to the Muséum National d'Histoire Naturelle, Paris (MNHN). At least two of the three species described by Bosc [1800] from North America were present in the MNHN around the turn of the 18th century, because they were illustrated by Coquebert (1801). However, no Lepidopteran types from the Bosc collection are now extant in the Paris museum (Zimsen 1964, P. Viette pers. comm.).

Bosc [1800] described three species of North American moths, but the paper was overlooked for over a century. The part of the journal in which Bosc's paper appears does not bear a date, but is headed "Prairial, an 8 de la République," meaning it was published in 1800, the eighth year of the French Revolution (an earlier part bears the heading "Germinel, an 6 de la République (Mars 1798)"). It appears that the first use of any of Bosc's names is that of Kaye and Lamont (1927), who applied one to a Trinidad species of Chrysauginae (Pyralidae). Of the three species described by Bosc [1800], only one, *Crambus adspergillus,* has been included in the North American literature (Franclemont and Todd 1983).

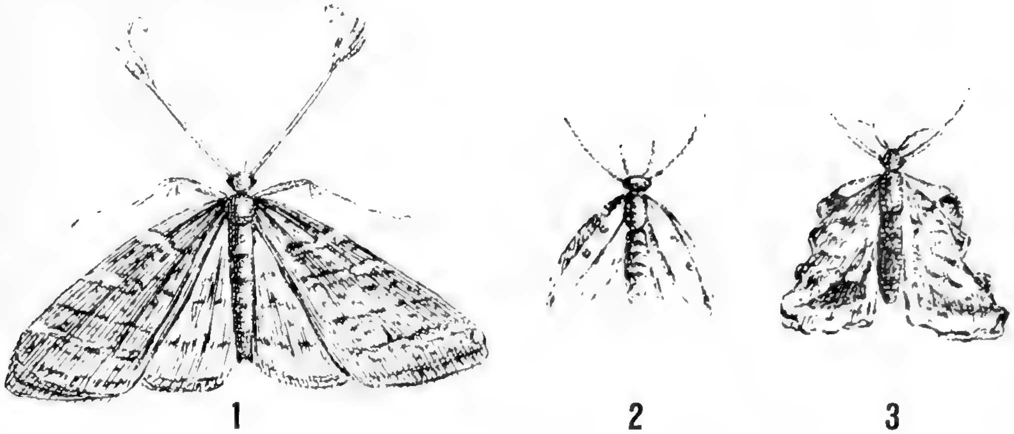
Although the types are not available for study, the descriptions and the figures presented by Bosc allow identification of the species. We have also checked the relevant bibliographies for homonymy and found that the three names are nomenclatorally available.

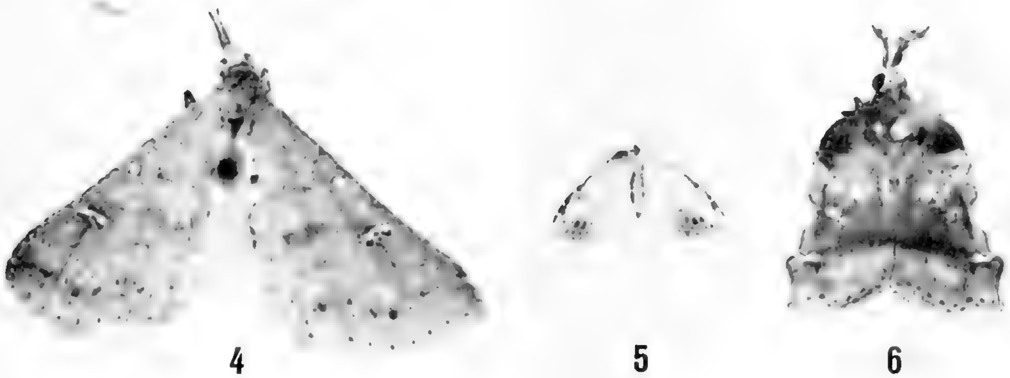
Two of the species, *Crambus adspergillus* and *Pyralis sacculana,* were illustrated in color by Coquebert de Montbret (1801), but no mention of *Alucita cereella* was included.

## NOCTUIDAE

### *Renia adspergillus* (Bosc)
Figs. 1, 4

*Crambus adspergillus* Bosc [1800]: 114, fig. 2 [Type locality: United States, "Caroline"].—Coquebert 1801: 72, pl. XVII, fig. 10A–B.





Figs. 1–3. Reproductions of illustrations from Bosc ([1800]: pl. VII), Fig. 1: *Crambus adspergillus*, Fig. 2: *Alucita cereella*, Fig. 3: *Pyralis sacculana*.

Figs. 4–6. Figures of specimens matching Bosc's illustrations: Fig. 4: *Renia adspergillus* (Bosc); Fig. 5: *Nola cereella* (Bosc); Fig. 6: *Clydonopteron sacculana* (Bosc). Figs. 4–6 approximately twice natural size.

*Renia larvalis* Grote 1872: 26 [Type locality: United States, Pennsylvania and Texas] [Synonymy by Franclemont and Todd 1983]

*Renia restrictalis* Grote 1872: 26 [Type locality: United States, Pennsylvania] [Synonymy by Franclemont and Todd 1983]

*Renia adspergillus* (Bosc).—Franclemont and Todd 1983.

Of the thirteen species of *Renia* recognized in North America, the figure resembles two species, previously described as *flavipunctalis* (Geyer) and *larvalis* (Grote). We follow Franclemont and Todd (1983: 121), who know the group well and were the first revisers, in recognizing *adspergillus* as conspecific with *larvalis*.

### *Nola cereella* (Bosc), NEW COMBINATION

Figs. 2, 5

*Alucita cereella* Bosc [1800]: 115, fig. 4 [Type locality: United States, "Caroline"]

*Nola sorghiella* Riley 1882: 187, pl. XI, fig. 1 [Type locality: United States, Alabama and Florida], n. syn.

*Nola portoricensis* Moeschler 1890: 118 [Type locality: Puerto Rico], n. syn.

Because of the small size of the figure and the quality of printing of the plate, this was the most difficult of the three Bosc species to identify. The pattern shown in the plate resembles species belonging to various families, and the plate shows two protruding appendages in front of the head that could be interpreted as either palpi or front legs. The shape and pattern resemble those of some species of *Donacaula* Meyrick (Pyralidae), especially the species belonging to the *melinella* group. The figure also resembles the pattern of some species of *Ethmia* Huebner (Oecophoridae), especially *E. trifurcella* (Chambers).

We have two main reasons for considering *cerealla* as conspecific with *sorghiella.* First, Bosc stated that it is a serious pest of grain. Secondly, although his description of the damage seems to be confused with that caused by the Hessian fly (*Mayetiola destructor* (Say), Diptera: Cecidomyiidae), and *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae), no other known grain pest resembles the figure of *cerealla.* Bosc's original description follows:

"Elle est cendrée. Les bords des aîles sont brans et paroissent renflés. On voít sur le disque de chaque aîle supérieure deux points bruns. Les aîles postérieures sont d'un gris brillant.

"Cette Alucite est la teigne qui, sous le nom d'Hessian fly, a fait, il y a environ douze ans, de grandes ravages dans les bleds d'Amérique, et a menacé de les étendre sur ceux d'Europe, ce qui a obligé le parlement d'Angleterre de proscrire les bleds qui venoient de ce pays. Sa larve a seize pattes; elle est d'un blanc verdâtre. Elle mange d'abord le germe du grain, puis la farine, ne laissant que l'écorce. Il n'y a qu'une larve dans chaque grain: elle est très-féconde et les générations se succèdent rapidement. Au défaut de bled, elle attaque le mais, et se multiplie considérablement dans les greniers où l'on conserve ce grain.

"Le meilleur moyen pour détruire la larva de cette Alucite, c'est de faire passer les grains dans une étuve très-chaude."

### PYRALIDAE

### ***Clydonopteron sacculana* (Bosc), NEW COMBINATION**

Figs. 3, 6

*Pyralis sacculana* Bosc [1800]: 115, fig. 3A, 3B [Type locality: United States, "Caroline"].—Coquebert 1801: 71, pl. XVII, fig. 7A–C.

*Clydonopteron tecomae* Riley 1880: 286, figs. 152–153 [Type locality: United States, probably Missouri], n. syn.

There is no doubt that *sacculana* is the same species described by Riley (1880) as *tecomae.* The peculiar shape of the wings and palpi, combined with the male structures on the costa of the forewing makes this species readily recognized. Kaye and Lamont (1927) and Amsel (1956) identified specimens of Chrysauginae from Trinidad and Venezuela as *sacculana* and placed it in the genus *Salobrena* Walker. Cashatt (1969) and Munroe (1983: 79), however, regard *Salobrena* and *Clydonopteron* Riley as distinct genera. Following their arrangement, we decided to place *sacculana* in *Clydonopteron.* Specimens that are similar to the North American *sacculana* have been collected throughout the neotropics to southern Brazil, and have been identified as *tecomae* (Hampson 1897: 649, Lima 1950: 20). However, a full revision of the group is needed to establish the number of species involved, their distribution, synonymy, and generic assignments. Also, we are not the first to recognize the synonymy of *sacculana* with *tecomae.* In the USNM collection there is a label, added by Carl Heinrich, proposing this synonymy, based on Coquebert (1801), but Heinrich never published his discovery.

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Agriculture (especially R. W. Hodges and D. C. Ferguson), for their assistance in verifying the identities of Bosc's species. R. Stanger translated Bosc's paper for us. The photographs of specimens were taken by V. Krantz of the Smithsonian Institution. M. J. Scoble helped verify the date of Bosc [1800]. Research for this paper was conducted while both authors had Smithsonian Institution fellowships. N. L. Evenhuis, D. C. Ferguson, and R. W. Hodges reviewed the manuscript.

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# THE INS AND OUTS OF A TROPICAL SOCIAL WASP NEST

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*Abstract.*—An extraordinarily large nest of the social wasp *Synoeca septentrionalis* is recorded from Costa Rica. The wasps had formed two holes through which they could enter or leave the nest, unlike the usual single-hole condition in the genus. A statistical test shows that one nest-hole was preferentially used for entering and the other for leaving, which presumably increased the colony's traffic efficiency. It is postulated that this tendency was a statistical result of small individual behavior differences, so that it need not require any organizing mechanism at the colony level.

*Key Words:* nest, *Synoeca,* Vespidae, wasp

Vespine and swarm-founding polistine wasps (Hymenoptera: Vespidae), except for the small genus *Apoica,* characteristically nest either in secure cavities or, more commonly, construct an envelope around the brood-combs (Jeanne 1975, Wenzel, in press). This allows them to restrict access to the interior of the nest. There have been occasional observations of nests with two or more entrance holes (Chopra 1925, Maidl 1934, Richards and Richards 1951, R. S. Jacobson, pers. comm.; pers. obs.), and Réaumur (1722) intimated that it is usual for *Vespula* sp. (probably *V. germanica* and/or *vulgaris*) nests to have two holes. It now seems certain, though, that all social wasps and bees with regular envelopes characteristically have one entrance hole. This is apparently taken for granted, although the nests of ants and termites often have many such holes.

*Synoeca septentrionalis* Richards is a widespread, conspicuous, swarm-founding polistine of Central and South America (Richards 1978). Its nest begins as a single comb flat against a tree trunk or limb or other substantial surface, surrounded by a domed envelope with prominent ridges running across it and typically with a round hole at the high end. As the colony grows, it may add a new lobe to the nest at the high end, obscuring the old hole and replacing it with a new one on the new lobe. I have seen occasional nests with two or three lobes in Costa Rica; Rau (1933) mentioned a five-lobed nest in Panama, and Buysson (1906) figured one from Mexico with six lobes, apparently the largest nest reported for the genus.

In early 1979, on a large fig tree (*Ficus* sp.) near the headquarters of the Santa Rosa National Park of Costa Rica, I found an active *S. septentrionalis* nest with two remarkable features. First, it consisted of nine lobes with a total length of about 3 meters (Fig. 1). Second, it had paired holes, each of the usual form and in the usual position (Fig. 2), with a combined perimeter of about 10 to 12 cm.

Réaumur (1722) reported that *Vespula* workers consistently enter through one of the two nest-holes and leave through the


1


2

Fig. 1. Nine-lobed nest of *Synoeca septentrionalis* in Santa Rosa National Park, Costa Rica. It is on the underside of a large branch at an angle of about 60° from horizontal.

Fig. 2. The uppermost lobes of the nest, showing the two entrance holes. Wasps on the envelope are about 20 mm long.

other. Although the quantitative study of behavior was nearly unknown in his time, we know that Réaumur made original observations on *Vespula* colonies, and it is reasonable to suppose that he found at least one nest with two holes and watched it long enough to gain an impression of directed traffic. Indeed, if a colony has considerable traffic through a bottleneck, it makes biological sense that any separation of the inward and outward streams will increase the efficiency of passage. Accordingly, I predicted that the very large Santa Rosa *Synoeca* colony would preferentially treat one of its two nest-holes as an entrance and the other as an exit.

Traffic at the nest was usually so heavy that I could not simultaneously monitor the direction of movement through both holes. In each of eight observations periods, I sequentially recorded a) the hole-choice of 50 wasps without regard to whether they entered or left the nest, b) direction of passage of 25 wasps at one hole, and c) direction of 25 wasps at the other hole. The observation periods were at various times when the wasps were active over the course of 10 days and totaled about two hours.

The hole-choice results (a) show greater use of the right-hand hole, which was the site of 280 (70%) of the 400 movements. The direction-of-passage data (b and c) show apparently more wasps leaving than entering the nest (Table 1). If the hole-choice bias is entered as a correction factor (e.g. by multiplying the left-hole figures by $\frac{3}{7}$ *or* the right-hole figures by $\frac{7}{3}$ in Table 1), though, the overall inward and outward traffic during the observation time is found to be almost

Table 1. Cumulative numbers of wasps leaving and entering the nest out of 25 moving through each hole during each of eight observations periods.

| | Left Hole | Right Hole | Total |
|---|---|---|---|
| Entering | 64 | 114 | 178 |
| Leaving | 136 | 86 | 222 |
| Total | 200 | 200 | |

Table 2. Percentage breakdown of total traffic during the observation time. Based on Table 1 and the hole-choice results, as explained in text.

| | Left Hole | Right Hole | Total |
|---|---|---|---|
| Entering | 9.6 | 39.9 | 49.5 |
| Leaving | 20.4 | 30.1 | 50.5 |
| Total | 30.0 | 70.0 | 100.0 |

identical. Table 2 thus gives the percentage breakdown of the traffic which would presumably have been recorded if I had been able to monitor all passages at once.

The bias-corrected results show a significant difference between the two holes in the directional distribution of traffic (Chi-square, $P < 0.01$). As seen in Table 2, it is equivalent to what would be recorded if 20% of the wasps consistently leave the nest by the left hole and return by the right hole, while the other 80% each tend to leave and return by the same hole.

There is some indication in *Synoeca* spp. of an unusual flexibility in nest construction (Vecht 1967, Overal 1982), which may account for this nest's two-holed condition. It makes little difference here whether this originated and was maintained as an adaptive response to extraordinarily large colony-size or through ordinary building errors. On the other hand, the origin of the tendency toward a plausibly more efficient flow of traffic is pertinent. There is no evidence for a higher organizing mechanism in *Synoeca* which could account for this, and we need not postulate any. The most parsimonious hypothesis is that the small behavioral differences which unavoidably arise between individuals have been summed to produce a meaningful phenomenon at the colony level.

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# NOTES ON THE GENUS *HYBRIZON* IN NORTH AMERICA (HYMENOPTERA: PAXYLOMMATIDAE)

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*Abstract.*—The two North American species of the unusual genus *Hybrizon* Fallén are redescribed from a large collection of specimens made in Virginia. Brief comments are made on the taxonomic placement of the genus and on the observed sex ratio of the collected material.

*Key Words:* taxonomy, Ichneumonoidea, ant-parasites

The genus *Hybrizon* Fallén is one of the most peculiar and taxonomically confusing groups in the Ichneumonoidae. It contains seven species (five Palearctic, two Nearctic) and is the only member in the family Paxylommatidae except for one undescribed genus from Japan. Because it lacks a second recurrent vein in the fore wing, the genus has often been classified as a subfamily of the Braconidae (Wesmael 1835, Curtis 1837, Haliday 1840, Muesebeck and Walkley 1951, Marsh 1963, Shenefelt 1969, van Achterberg 1976, Watanabe 1984). However, it also has been classified as a subfamily of the Ichneumonidae (Rasnitsyn 1980, Gauld 1984), or in a distinct family (Watanabe 1946, Tobias 1968, Marsh 1971, 1979, Mason 1981, van Achterberg 1984, Marsh et al. 1987). Mason (1981) argued convincingly that *Hybrizon* should be excluded from the Braconidae because it lacks a critical synapomorphy of the family, namely, the fusion of abdominal terga 2 and 3. Furthermore, van Achterberg (1984) gave two synapomorphies of wing venation that show the Paxylommatidae are more closely related to the Ichneumonidae than to the Braconidae. The same conclusion was reached by Sharkey and Wahl (1987), who suggested that *Hybrizon* might be placed within the Ichneumonidae. This action had already been proposed by Rasnitsyn (1980) who classified *Hybrizon* as a subfamily of the Ichneumonidae. However, Mason (1981) argued against this in favor of a separate family classification, the Paxylommatidae, and I have followed his classification in this paper.

During the summers of 1986 and 1987, my colleague, David R. Smith, operated several Malaise traps in two locations in Virginia, at his home in Annandale (a suburb of Washington, D.C.) and near Cuckoo in Louisa County. Approximately 200 specimens of *Hybrizon* were collected during these two years representing two species. Prior to this the U.S. National Museum contained only about 50 specimens of the genus. Approximately ⅔ of the specimens collected by Smith are *rileyi* (Ashmead); the other ⅓ are a distinct species which I thought was undescribed but now have identified as the previously unknown female of *flavocinctus* (Ashmead). I have provided descriptions and a key to separate the species below. Additional specimens were borrowed from the Canadian National Collection, Ottawa, Canada (M. Sharkey), the American Entomological Institute, Gainesville, Florida (H. Townes), the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (S. Shaw), and the Rijksmuseum van Natuurlijke Histoire, Leiden, The Netherlands (C. van Achterberg).

The biology of these unusual wasps has not been satisfactorily established. They are associated with ant nests and are likely to be endoparasitoids of ant larvae. Donisthorpe and Wilkinson (1930) give the most extensive review of the biology.

Of interest is the high ratio of females to males of the North American species in the National Collection, 241:14 in *rileyi* and 137:5 in *flavocinctus.* Female biased sex ratios are predicted by the local mate competition (LMC) model of Hamilton (1967), ". . . where females place offspring in discrete patches of the resource (in this case, ant colonies), and those offspring mate randomly in their patch before female offspring disperse to colonize new patches" (Waage 1985). On the other hand, the observed female biased sex ratio could merely be an artifact of collecting techniques, assuming that mating occurs in or near ant colonies and females searching for new colonies are the main dispersers. Thus, random sweeping or flight intercept traps would produce mostly females, whereas collections made in ant colonies might yield a more balanced sex ratio.

## Family Paxylommatidae

Pachylommatoidae Foerster, 1862: 247. Oldest family-group name (see Mason 1981 for discussion).

## Hybrizon Fallén

*Hybrizon* Fallén, 1813, p. 19. No species. Type-species: *Hybrizon latebricola* Nees, 1834. Monotypic, first included species by Nees (1834:28).

*Paxylomma* de Brébisson, 1825: 23. Type-species: *Paxylomma buccatum* de Brébisson. Monotypic. Synonymy by Wesmael, 1835.

*Plancus* Curtis, 1833: 188. Type-species: *Plancus apicalis* Curtis. Monotypic. Synonymy by Stephens, 1835.

*Eurypterna* Foerster, 1862: 247. Type-species: *Paxylomma cremieri* Romand. Monotypic. Synonymy by Marshall, 1891.

*Eupachylomma* Ashmead, 1894: 58. Type-species: *Wesmaelia rileyi* Ashmead. Original designation. Synonymy by Watanabe, 1935.

*Ogkosoma* Haupt, 1913: 52. Type-species: *Ogkosoma schwarzi* Haupt. Monotypic. Synonymy by Strand, 1914.

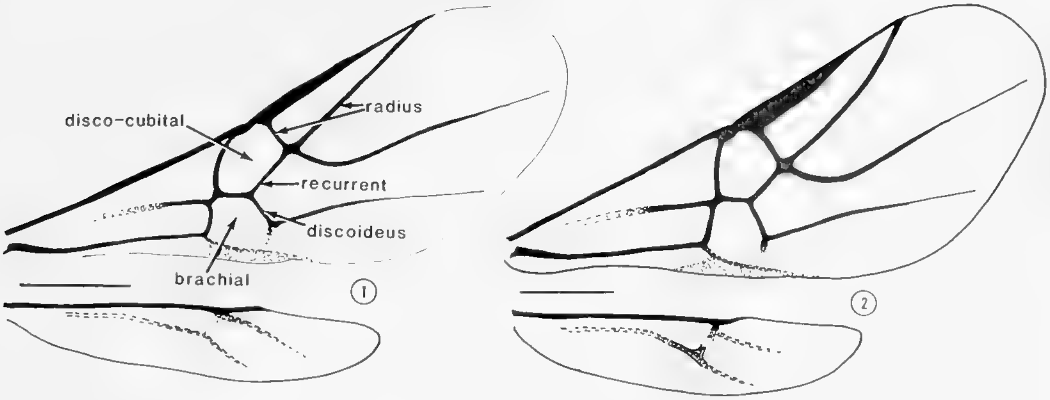
The names *Paxyloma* (Stephens 1835), *Paxylomme* (Wesmael 1835), *Paxyllomma* (Curtis 1837), *Paxylloma* (Blanchard 1840), and *Pachylomma* (Ratzeburg 1848) are all to be considered emendations of *Paxylomma* (see Shenefelt 1969 and Mason 1981).

Because of the small size of these wasps and the lack of a second recurrent vein in the fore wing, *Hybrizon* will key to Braconidae in most general textbooks with keys to Hymenoptera families. In view of this, *Hybrizon* was included by Marsh et al. (1987) in their identification manual for North American genera of Braconidae. The genus can be diagnosed by reference to couplet 1 of that key and the associated figures. Adult *Hybrizon* have a distinctive habitus (Fig. 3): narrow head with bulging eyes and deep anterior tentorial pits (Figs. 6, 7), strongly arched thorax, long spindly legs, and long thin abdomen.

The two North American species of *Hybrizon* can be separated by the following key.

Ocelli small, ocell-ocular distance at least equal to diameter of lateral ocellus, often greater (Fig. 9); first segment of radius in fore wing shorter than first segment of discoideus and about ½ length of recurrent vein, branchial cell not as tall as discocubital cell (Fig. 1); head, thorax and abdomen usually entirely black ........... *rileyi* (Ashmead)

Ocelli larger, ocell-ocular distance less than diameter of lateral ocellus, often less than half (Fig. 8);



Figs. 1, 2. Wings of *Hybrizon* species. 1, *H. rileyi* (Ashmead). 2, *H. flavocinctus* (Ashmead) (scale = 0.5 mm).

first segment of radius equal to or longer than discoideus and about ⅔ length of recurrent vein; brachial cell equal in height to disco-cubital cell (Fig. 2); head black, at least pronotum, mesopleuron and base of abdominal terga 3 and 4 honey yellow, sometimes thorax and abdomen extensively marked with honey yellow . . *flavocinctus* (Ashmead)

### Hybrizon rileyi (Ashmead)

Figs. 1, 3, 4, 7, 9

*Wesmaelia rileyi* Ashmead, 1899: 641. Holotype female in U.S. National Museum, Washington, D.C.

Female. Length of body, 2–3 mm. Color: head black, clypeus and mouthparts white; antennal scape and pedicel yellow, flagellum black; thorax black or dark brown, rarely deep honey yellow; legs yellow with hind femur, tibia, and coxa often light brown; tegula yellow; abdomen black or dark brown, rarely basal segments dark honey yellow. Head: very weakly reticulate, smooth and shining; ocellar-ocular distance equal to or greater than diameter of lateral ocellus (Fig. 9); clypeus lengthened, apical margin well below level of lower eye margin, malar space slanted (Fig. 7); antenna with 11 flagellomeres. Thorax: pro and mesothorax smooth and shining; propodeum irregularly rugose, without any indication of median longitudinal carina. Abdomen: terga smooth and shining, terga 1 and 2 sometimes weakly striate at base (Fig. 4). Wings (Fig. 1): first segment of radius shorter than first segment of discoideus and about ½ length of recurrent vein, brachial cell not as tall as disco-cubital cell.

Male. Essentially similar to female.

Type locality. UNITED STATES: Oxford, Indiana.

Material examined. 241 ♀♀, 14 ♂♂ from the following states and provinces: District of Columbia, Georgia, Indiana, Iowa, Kansas, Maine, Maryland, Michigan, New Hampshire, New Jersey, New York, North Carolina, Nova Scotia, Ontario, Pennsylvania, Quebec, South Carolina, Virginia, West Virginia, Wisconsin.

Biology. The type material is recorded as being reared from *Toxopotera* (= *Schizaphis*) *graminum*, but this is probably not correct. Three specimens from New Hampshire are labelled "Attracted to disturbed nest of *Lasius alienus*."

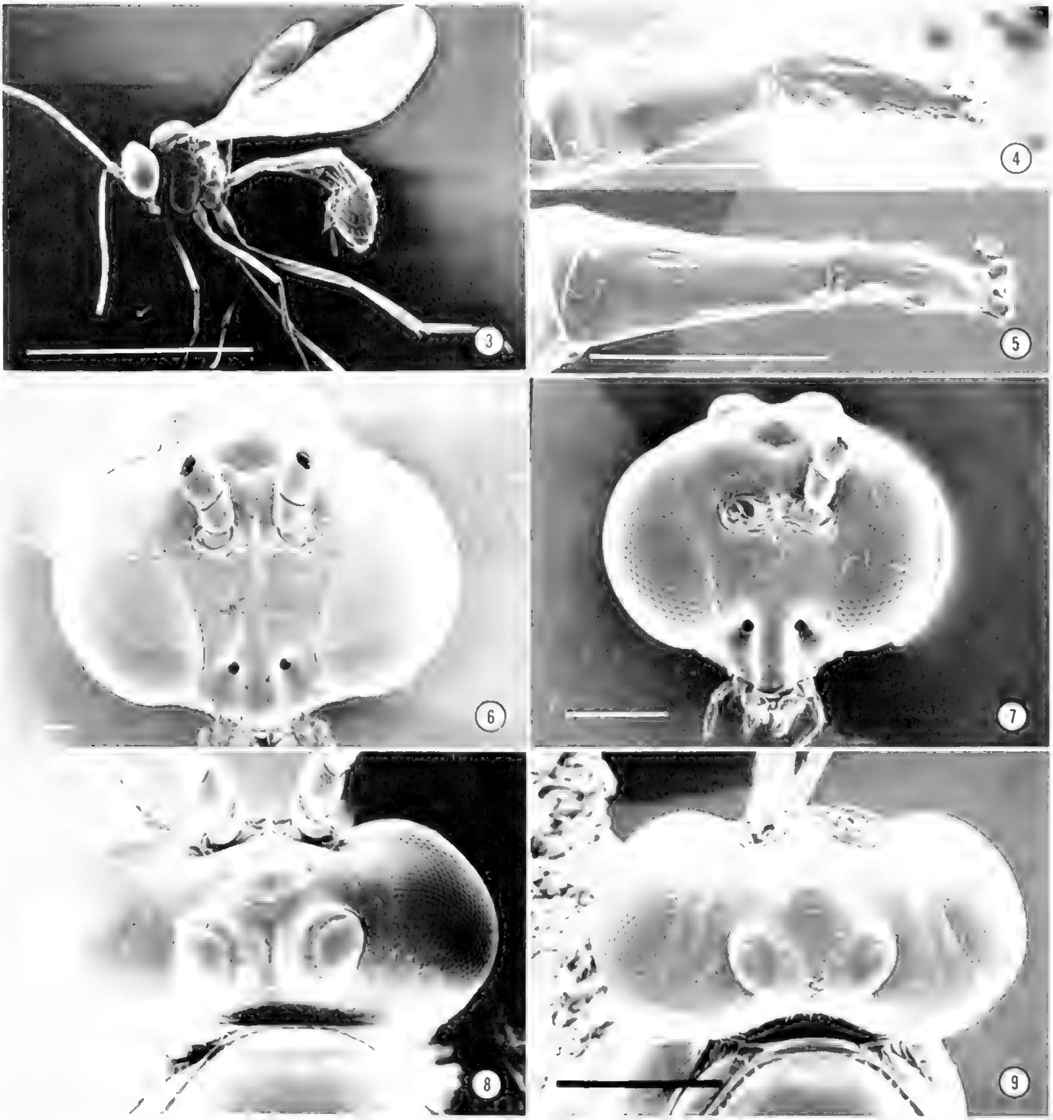
This species is easily distinguished from *flavocinctus* by its darker color, smaller ocelli, and wing venation.

### Hybrizon flavocinctus (Ashmead)

Figs. 2, 5, 6, 8

*Eupachylomma flavocincta* Ashmead, 1894: 59. Holotype female in U.S. National Museum, Washington, D.C.

Female. Length of body, 3.5–4 mm. Color: head black, clypeus and mouth parts light yellow; antennal scape and pedicel yellow, flagellum black; prothorax honey yellow;



Figs. 3–9. *Hybrizon* species. 3, *H. rileyi* (Ashmead), habitus (scale = 2 mm). 4, *H. rileyi*, abdominal terga 1–2 (scale = 500 μ). 5, *H. flavocinctus* (Ashmead), abdominal terga 1–2 (scale = 500 μ). 6, *H. flavocinctus*, face (scale = 100 μ). 7, *H. rileyi*, face (scale = 200 μ). 8, *H. flavocinctus*, vertex (scale = 200 μ). 9, *H. rileyi*, vertex (scale = 200 μ).

mesonotum dark brown or black, sometimes with yellow longitudinal lines; scutellum yellow with brown spot at base; mesopleuron varying from entirely brown to yellow; propodeum dark brown; tegula yellow; legs yellow, hind femur, tibia, and coxa light brown; abdomen brown, terga 3 and 4 yellow at base. Head: reticulate and dull; ocell-ocular distance less than diameter of lateral ocellus, inner edge of each ocellus margined by a scrobiculate groove (Fig. 8); clypeus short, apical margin only slightly below level of lower eye margin, malar space nearly horizontal, eyes bulging below (Fig. 6); antenna with 11 flagellomeres. Thorax: pro- and mesothorax smooth and shining; propodeum irregularly rugose, often with a short median carina. Abdomen: first and second terga usually distinctly striate (Fig. 5), rest of terga smooth and shining. Wings (Fig. 2): first segment of radius equal to or longer than discoideus and about ⅔ length of recurrent vein, brachial cell about as tall as discocubital cell.

Male. Essentially as in female, occasionally body mostly honey yellow.

Type locality. UNITED STATES: Washington, D.C.

Material examined. 137 ♀♀, 5 ♂♂ from the following states and provinces: District of Columbia, Maryland, Michigan, New York, Ontario, Virginia, Wisconsin.

Biology. Unknown.

Prior to this study, the only authentically determined specimen of *flavocinctus* was the male holotype. The large number of female specimens collected in Virginia were generally much darker in color than the holotype and I had thought them to be an undescribed species. After closer examination, they agree morphologically with the holotype and I now consider them to be the undescribed female of *flavocinctus.*

This species differs from *rileyi* in its larger size, larger ocelli, generally lighter body color, and wing venation. It is also very similar to the European *buccatus* (de Brébisson) which is distinguished by its darker body color, by having stronger sculpturing on the head which is almost punctate, and by having a few punctures on the mesonotum along where the notauli would be.

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Scott Shaw, Museum of Comparative Zoology, Harvard University, read the manuscript and offered many helpful suggestions for improvement, especially the sections on classification and biology, for which I am grateful. David Wahl, American Entomological Institute, Gainesville, Florida and Robert Smiley, Systematic Entomology Laboratory, Beltsville, Maryland also offered useful comments on the manuscript. Thanks also go to David Smith for operating the Malaise traps that produced the specimens which motivated this study.

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# THE GENERA *ATAENOGERA* AND *PHYCUS* IN THE NEW WORLD (DIPTERA: THEREVIDAE: PHYCINAE)

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*Abstract.*—Two of the three species names available for the New World genus *Ataenogera* Kröber are synonymized in this paper. The genus *Phycus* Walker, previously unknown from the New World, is represented here by two new species. A key to the New World species of these two genera is provided along with species descriptions and distributions. Descriptions of the pupal stage of *Ataenogera abdominalis* and of the larva and pupa of ***Phycus frommeri* n. sp.** are included.

*Key Words:* Diptera, Therevidae, *Phycus, Ataenogera,* New World, species descriptions, distribution

In a revisionary monograph on the Nearctic genera of Therevidae, Irwin and Lyneborg (1981) described several new genera, redescribed others, and assigned an undescribed therevid species from northwestern Mexico and southern California to the genus *Phycus.* They separated the genera *Phycus* Walker and *Ataenogera* Kröber on the basis of several morphological characteristics and suggested that species of *Ataenogera* have no close relatives in the Old World other than *Phycus.* Subsequently, Lyneborg (1983) characterized and critically evaluated the Old World species of *Phycus.*

Because *Phycus* was unknown from the New World prior to Irwin and Lyneborg's study, we undertook to compare that genus to the closely related *Ataenogera.* The species in these genera are similar in gross structure and are placed together within the subfamily Phycinae. Because *Ataenogera* and *Phycus* are clearly separated as a new clade from such New World phycine genera as *Henicomyia* Coquillett on the one hand, and *Pherocera* Cole, *Schlingeria* Irwin, and *Parapherocera* Irwin on the other (Irwin and Lyneborg 1981), we elected to describe and diagnose their New World species here in a single publication.

## METHODS

The morphological terminology used for the male terminalia was originally defined and described by Lyneborg (1968) and subsequently modified by Lyneborg (1972, 1976, 1978) and Irwin (1977a, b); that for the female terminalia was defined and described by Irwin (1976); that for the larva and pupa follows Irwin (1972). Other morphological features are described in terminology generally accepted in the literature on Diptera. The range for each measurement and ratio is followed by the average; the range for each setal count is followed by the mode.

Each specimen was assigned a THEREVIDAE/M. E. IRWIN/SPECIMEN number attached to the specimen. This number is used to associate the ecological and label data with a given specimen and is printed in italics in this paper. The data are incorporated into an automated data management system originally designed by Rauch (1970).

To conserve space and include as much information as possible about each specimen, a layout adopted from Irwin (1983) is used in the "Specimens Examined" section of each species. Many of the terms used there are explained by Stuckenberg and Irwin (1973). The layout follows these typographical conventions:

1) Full capitals: LARGEST POLITICAL UNIT (country, or state within the United States).

2) Boldface type: **intermediate political unit** (state or province outside the United States or county within the United States) and **elevation** expressed in m above sea level.

3) Roman or normal print: smallest political unit (city or town) and modifier of that unit (distances in km, direction, and subunits of that unit).

4) Collector names. Acronyms were used for the following collectors: M. E. Irwin, MEI; R. M. Worley, RMW; S. I. Frommer, SIF.

5) Numbers of specimens is followed by the sex designation M for male or F for female.

6) A semicolon terminates one series of specimens and signals the beginning of the next. Data not repeated in a subsequent series are the same as those of preceding series.

Depositories.—Paratypes of *Phycus frommeri* n. sp. have been deposited in the following museums: AMNH, American Museum of Natural History, New York; ANSP, Academy of Natural Sciences, Philadelphia; ASU, Arizona State University, Tempe; AMS, Australian Museum, Sydney; BMH, Bernice P. Bishop Museum, Honolulu, Hawaii; BMNH, British Museum of Natural History, London; BYU, Brigham Young University, Provo, Utah; CAS, California Academy of Sciences, San Francisco; CIS, California Insect Survey, University of California, Berkeley; CMNH, Field Museum of Natural History, Chicago; CMP, Carnegie Museum, Pittsburgh; CNC, Canadian National Collection, Ottawa; CSDA, California State Department of Agriculture, Sacramento; CSIRO, Commonwealth Scientific Industrial Research Organization, Canberra, Australia; CSU, Colorado State University, Fort Collins; CU, Cornell University, Ithaca; DEI, Deutsches Entomologische Institut, Berlin, East Germany; DSIR, Department of Scientific and Industrial Research, Nelson, New Zealand; DZSA, Departamento de Zoologia Agricultura, São Paulo, Brazil; EEA, Estación Experimental Agronómica, Universidad de Chile, Maipú; FSCA, Florida State Collection of Arthropods, Gainesville; IAS, Institute of Agricultural Sciences, Tokyo; IE, Instituto di Entomologia, Bologna, Italy; IML, Instituto Miguel Lillo, Tucumán, Argentina; INHS, Illinois Natural History Survey, Champaign; INIA, Instituto Nacional de Investigaciones Agrícolas, Chapingo, Mexico; IOC, Instituto Oswaldo Cruz, Rio de Janeiro, Brazil; IRSN, Institut Royal des Sciences Naturelle de Belgique, Brussels; ISU, Iowa State University, Ames; ITM, Instituto Technólogico y de Estudios Superiores, Monterrey, Mexico; KSU, Kansas State University, Manhattan; KUF, Kyushu University, Fukuoka, Japan; LACM, Natural History Museum of Los Angeles County, Los Angeles; Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; MEI, M. E. Irwin Collection; MHN, Museo de Historia Natural Javier Prado, Lima, Peru; MMB, Moravske Museum, Brno, Czechoslovakia; MNH, Musei Nationalis Hungarici, Budapest, Hungary; MNHN, Museum National d'Histoire Naturelle, Paris, France; MSU, Michigan State University, East Lansing; NCSU, North Carolina State University, Raleigh; NMB, Naturhistorisches Museum, Basel, Switzerland; NMP, Natal Museum, Pietermaritzburg, South Africa; NMSU, New Mexico State University, Las Cruces; Nevada State Department of Agriculture, Reno; OSM, Ohio State Museum, Columbus; OSU, Oregon State University, Corvallis; PAS, Polish Academy of Sciences, Warsaw, Poland; RNHL, Rijkmuseum van Natuurlijke Historie, Leiden, The Netherlands; SDAP, State Department of Agriculture, Harrisburg, Pennsylvania; SDCM, San Diego County Museum, San Diego; SJSC, San Jose State University, San Jose, California; SMN, Staatlichen Museum für Naturkunde, Stuttgart, West Germany; SWRS, Southwestern Research Station (AMNH), Portal, Arizona; TAM, Texas Agricultural and Mechanical University, College Station; UA, University of Arizona, Tucson; UAC, University of Alberta, Edmonton, Alberta, Canada; UBC, University of British Columbia, Vancouver, Canada; UCD, University of California, Davis; UCM, University of Colorado Museum, Boulder; UCR, University of California Riverside; UCVM, Universidad Central de Venezuela, Maracay, Venezuela; UG, University of Georgia, Athens; UI, University of Idaho, Moscow; UK, University of Kansas, Lawrence; UM, University of Minnesota, Saint Paul; UMA, University of Michigan, Ann Arbor; UNLP, Museo de Ciecias Naturales, Universidad Nacional de La Plata, La Plata, Argentina; USI, University of Southern Illinois, Carbondale; USNM, United States National Museum, Washington, D.C.; USSR, Zoological Institute USSR, Leningrad; USU, Utah State University, Logan; UTA, University of Texas, Austin; UTI, University of Tel Aviv, Israel; UU, University of Utah, Salt Lake City; UW, University of Wisconsin, Madison; UZM, Universitetets Zoologiske Museum, Copenhagen, Denmark; VNM, Naturhistorisches Museum Vienna, Austria; WSU, Washington State University, Pullman; ZIB, Zoologisches Institut, Berlin, West Germany; ZSI, Zoological Survey of India Collection, Calcutta, India. The paratypes of *Phycus frontalis* n. sp. are deposited in the following museums: AMNH, American Museum of Natural History, New York; INHS, Illinois Natural History Survey, Champaign; USNM, United States National Museum, Washington, D.C.

### KEY TO NEW WORLD SPECIES OF *ATAENOGERA* AND *PHYCUS*

1. Maxillary palpus one-segmented (Fig. 3); eye margins distinctly divergent from level of ocellar tubercle toward genae (Fig. 2); discal cell pointed basally (Fig. 4); sternites 5–8 in males, 5–7 in females (Fig. 10) with numerous lanceolate setae ventrally; male genitalia with large, subtriangular hypandrium (Fig. 8) ......... ................ *Ataenogera abdominalis* Kröber

– Maxillary palpus two-segmented (Fig. 18); eye margins divergent slightly from level of ocellar tubercle toward genae (Fig. 17); discal cell truncate basally (Fig. 19); sternites lacking lanceolate setae; male genitalia lacking hypandrium or much reduced. (*Phycus* Walker) .......... 2

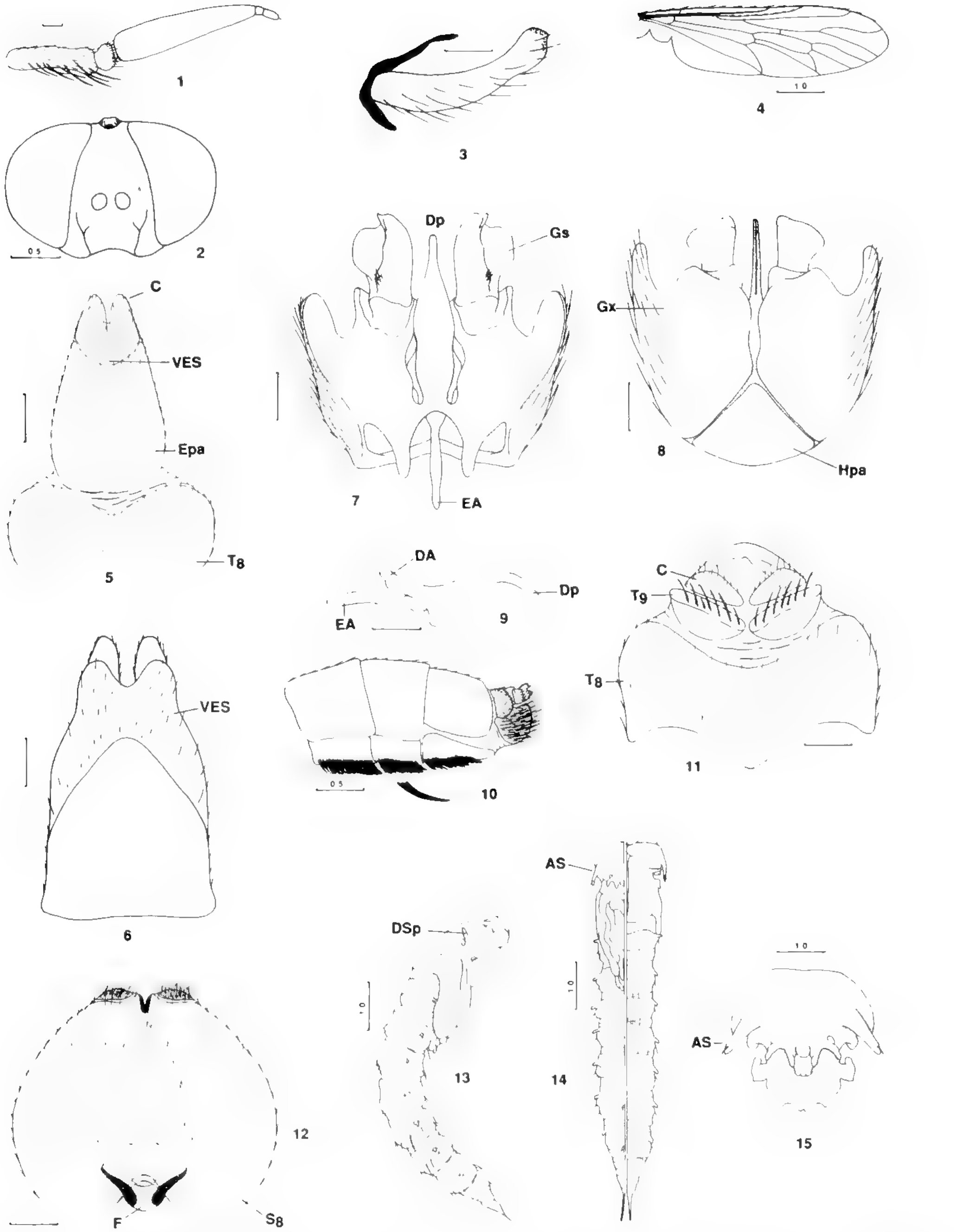
2. Eyes separated dorsally by distance greater than width of ocellar tubercle (Fig. 17); width of frons at level of lateral ocelli greater than 0.5 times width at level of antennal bases; posterolateral extensions of gonocoxites short, thick in ventral view (Fig. 23) .... .. ........................ *Phycus frommeri* n. sp.

– Eyes separated dorsally only by width of ocellar tubercle (Fig. 35); width of frons at level of lateral ocelli less than 0.5 times width at level of antennal bases; posterolateral extensions of gonocoxites narrow, attenuate in ventral view (Fig. 39) ............... *Phycus frontalis* n. sp.

Superficially, the genus *Ataenogera* is morphologically similar to *Phycus,* the two genera are however quite distinct. The best distinguishing characteristics are: (a) maxillary palpus two-segmented in *Phycus,* one-segmented in *Ataenogera*; (b) fore coxae have 1–2 apical setae in *Phycus,* 4–6 apical setae in *Ataenogera*; (c) ventral epandrial sclerite fused anteriorly with epandrium in *Phycus,* fused laterally with epandrium in *Ataenogera*; (d) hypandrium extremely small or absent in *Phycus,* large in *Ataenogera*; (e) ventral apodeme of aedeagus composed of two long, narrow rods in *Phycus,* very reduced, appearing absent in *Ataenogera.*

### Genus *Ataenogera* Kröber

*Ataenogera* Kröber (1914: 31): Malloch (1932: 255). Type species: *A. abdominalis* Kröber, by monotypy.



Figs. 1–15. *Ataenogera abdominalis.*—1. Antenna (*5747*). 2. Head of male, frontal view (*5747*). 3. Maxillary palpus, lateral view (*5747*). 4. Wing, dorsal view (*5747*). 5. Male tergite 8, epandrium, cerci, and ventral epandrial sclerite, dorsal view (*5761*). 6. Male ventral epandrial sclerite, ventral view (*5761*). 7. Male gonocoxites and gonostylus, dorsal view (*5761*). 8. Male gonocoxites and gonostylus, ventral view (*5761*). 9. Male aedeagus, lateral view (*5761*). 10. Female abdomen, terminal segments, lateral view with enlargement of ventral lanceolate setae (*5752*). 11. Female terminalia, dorsal view (*5752*). 12. Female terminalia, ventral view (*5752*). 13. Pupal exuvium lateral view (*5764*). 14. Pupa exuvium, ventral view (left), dorsal view (right) (*5764*). 15. Frontal plate (*5764*). Abbreviations: (AS) antennal sheath; (C) cercus; (DA) dorsal apodeme; (Dp) distiphallus; (DSp) dorsal spiracle; (EA) ejaculatory apodeme; (Epa) epandrium; (F) furca; (Gs) gonostylus; (Gx) gonocoxites; (Hpa) hypandrium; ($S_8$) sternite 8; ($T_8$) tergite 8; ($T_9$) tergite 9; (VES) ventral epandrial sclerite. Scale = 0.1 mm, unless otherwise indicated.

*Leptocera* Kröber (1928: 117). Type species: *L. gracilis* Kröber by monotypy. Preoccupied by Olivier (1813: 489).

*Ziehenia* Kröber (1929: January: 434). New name for *Leptocera* Kröber.

*Epileptocera* Richards (1929: August: 171). Unjustified new name for *Leptocera* Kröber.

Moderate-sized, slender flies.

Head.—Frons (Fig. 2) of both sexes at its narrowest as wide as ocellar tubercle, tomentum brownish gray; setae sparse, dorsolateral to antennal bases and in males in two lateral rows ventral to ocellar tubercle; male eyes dichoptic, eye margin diverges distinctly from level of ocellar tubercle towards gena, facets equal, setae absent; parafacial lacking setae; head slightly protrudes at antennal level; facial and genal callus absent; length of antenna 1.3–2.0 times head depth; antenna long (Fig. 1); scape cylindrical; pedicel subtriangular; flagellum elongate, tapered apically, setae absent; style terminal, two-segmented, with minute terminal spine; clypeus concave, setae absent; maxillary palpus one-segmented (Fig. 3).

Thorax.—np 2–3, sa 1, pa 1, dc 0–1, sc 1. Vittae absent; mesonotal setae moderately long, subappressed; prosternum bare in and around central depression; pleural setae elongate, scattered on propleuron and dorsal fourth of anepisternum. Wing (Fig. 4).—Ground color hyaline to pale brown, clouding apparent near apex; veins brown; pterostigma absent; setulae dorsal on $R_1$; subcostal cell and cell $r_1$ elongate, open; veins $R_4$ and $R_5$ subequal; cell $r_4$ large, encloses apex of wing, length 1.5–2.6 times width at apex; veins $M_1$, $M_2$, and $M_3$ originate separately from apical margin of discal cell; cell $m_3$ generally closed, petiolate; discal cell acute basally; posterior cells 5; posterior cubital cell closed with short petiole; m-cu/r-m subequal. Legs.—Fore coxae moderately long, sparsely haired, bare on posterior surface, with 4–6 stiff setae on anterior surface; femora lacking stiff setae; tibiae with several stiff apical setae.

Abdomen.—Slender, especially in male, longer than wide, laterally compressed; dorsum convex, shining fuscous to black; setae sparse, short, sternites 5–8 in males, 5–7 in females (Fig. 10) with numerous lanceolate setae ventrally. Male terminalia (Figs. 5–9).—Tergite 8 ($T_8$) wide, deeply constricted medially. Sternite 8 large, simple. Epandrium (Epa), longer in midline than maximum width, posterior margin broadly emarginate; cerci (C) extending posteriorly beyond epandrium and ventral epandrial sclerite; ventral epandrial sclerite, ventral view (VES) setose, attached laterally to epandrium with no membranous attachment to aedeagus, posterior margin broadly emarginate. Gonocoxites in ventral view not united ventrally, attached anteriorly by narrow membrane; hypandrium (Hpa) broad, subtriangular, large. Aedeagus with dorsal apodeme laterally attached by a strongly sclerotized bridge to basal section of paramere; distiphallus narrow, downwardly directed; ventral apodeme lacking; ejaculatory apodeme (EA) large, apical fourth expanded. Female terminalia (Figs. 11–12).—Tergite 8 ($T_8$) subrectangular, wider than long, posterior margin broadly concave. Tergite 9 ($T_9$) suboval, separated medially, with several strong setae along posterior margin. Cerci (C) subtriangular, membranous, with scattered setae. Sternite 8 ($S_8$) large, as long as wide, with short median emargination on posterior margin. Sternite 9 greatly modified, invaginated beneath sternite 8 to form internal furca (F).

Immature stages.—Characteristics of pupal exuvium (Figs. 13–15) in description of species.

### *Ataenogera abdominalis* Kröber

*Ataenogera abdominalis* Kröber (1914: 31): Malloch (1932: 255).

*Leptocera gracilis* Kröber (1928: 118). New synonym.

*Henicomyia brevicornis* Bromley (1934: 361). New synonym.

Derivation of name.—*abdomen* (Latin) = belly; *alis* (Latin) = pertaining to.

Diagnosis.—*Ataenogera abdominalis* is the only recognized species in this genus. The characteristics given in the key and description of the genus separate it from *Phycus.* Examination of the type specimens of *Ataenogera abdominalis, Leptocera gracilis,* and *Henicomyia brevicornis* revealed no distinctive characteristics that would justify retaining them as separate species. Some variation was noted in the color pattern of the fore and middle femora but this appears to represent clinal variation.

Description of male lectotype (*5759*).—Body length 8.8 mm.

Head.—Head depth 0.84 mm. Ocellar tubercle fuscous, subshiny to lightly tomentose; ocellar setae black, moderately long, scattered. Eyes fuscous. Frons fuscous, tomentum light gray, variable, with silver pile lateral to antennal bases, setae (Fig. 2) white, moderately long, dorsolateral to antennal bases and dark brown, short, in lateral row ventral to ocellar tubercle. Antenna (Fig. 1) brown, pruinosity light gray, length of antenna 1.9 times head depth; length of scape 0.40 mm, 2.9 times width, 4.0 times length of pedicel, setae dark brown, short, with several stiff setae ventrally; length of pedicel 0.10 mm, 0.7 times width, setae dark brown, in apical band; length of flagellum 1.02 mm, 5.7 times width, 2.6 times length of scape; length of basal stylomere 0.02 mm, length of apical stylomere 0.06 mm. Parafacial narrow, tomentum dense silver. Genal setae white, elongate, scattered. Maxillary palpus (Fig. 3) dark brown, pruinosity light gray, length 0.52 mm, 5.2 times width, setae white to pale yellow, elongate, scattered. Labellum black, pruinosity light gray; setae fuscous, short, scattered. Postocular setae white, elongate, abundant ventrally becoming black, short, appressed dorsally.

Thorax.—np 2, sa 1, pa 1, dc 0, sc 1. Dark brown in ground color, tomentum dark gray; setae white, moderately long, subappressed. Postpronotal lobe concolorous with thorax; setae white, moderately long, scattered. Pleuron fuscous, tomentum dense gray, anepisternum with ventral three-fourths glossy. Pleural setae white, elongate, scattered on propleuron, scattered on dorsal fourth of anepisternum, absent on remaining pleural sclerites. Scutellum fuscous, tomentum dark gray. Postnotum and laterotergite dark brown, subshiny to pruinosity light gray; setae on laterotergite white, elongate, abundant. Wing (Fig. 4).—Length 5.7 mm, 3.8 times width. Membrane hyaline. Pterostigma dark brown, narrow. Halter dark brown. Legs.—Dark brown, tomentum dark gray, concolorous. Anterior tubercle on hind coxa round, fuscous, apical half pale yellow.

Abdomen.—Dark brown, subshiny, tergites 2–4 with narrow, white posterior margin; setae black, short, appressed on dark areas, white, moderately long on white posterior margin, sternites 5–8 with dark brown lanceolate setae (Fig. 10). Male terminalia.—Characteristics given in description of genus.

Variation in males (N = 10).—Body length 6.3–8.8, 7.9 mm. Head depth 0.60–0.84, 0.70 mm. The frons varies in having the tomentum entire to the ventral third glossy. Length of antenna 1.8–2.2, 2.0 times head depth; length of scape 0.32–0.46, 0.40 mm, 2.9–4.2, 3.6 times width, 3.2–5.3, 4.4 times length of pedicel; length of pedicel 0.08–0.10, 0.09 mm, 0.7–0.8, 0.8 times width; length of flagellum 0.74–1.02, 0.84 mm, 4.1–5.7, 4.9 times width, 1.6–2.6, 2.1 times length of scape; length of basal stylomere 0.02 mm, length of apical stylomere 0.06–0.10, 0.08 mm. Length of maxillary palpus 0.36–0.52, 0.44 mm, 5.2–7.3, 5.9 times width. Notopleural setae 2–3, 2. Dorsocentral setae 0–1, 0. Wing length 4.5–5.7, 5.0 mm, 3.5–3.8, 3.7 times width. A cline exists in the color pattern of the fore and middle femora from dark brown in specimens from Argentina, Paraguay, and southern Brazil to dark yellow in specimens from Mexico.

Female.—Similar to male with following exceptions (N = 10). Body length 7.5–8.6, 7.9 mm. Head depth 0.84–0.98, 0.92 mm.

The frons shows variation similar to male. Length of antenna 1.3–1.5, 1.4 times head depth; length of scape 0.44–0.50, 0.47 mm, 3.7–5.0, 4.2 times width, 4.8–6.0, 5.4 times length of pedicel; length of pedicel 0.08–0.10, 0.08 mm, 0.67–0.83, 0.75 times width; length of flagellum 0.70–0.72, 0.71 mm, 3.9–4.5, 4.3 times width, 1.4–1.6, 1.5 times length of scape; length of basal stylomere 0.02–0.04, 0.03 mm, length of apical stylomere 0.06–0.12, 0.08 mm. Fore and middle femora show variation similar to males. Characteristics of terminalia (Figs. 11–12) given in description of genus.

Seasonal activity.—In the specimens examined, adults were taken throughout the year with no difference in the collecting period between Central America and southern South America. Females (25) were collected 2.8 times more often than males (9).

Pupa (Figs. 13–15).—Length 8.0 mm (N = 1), width 1.5 mm. Alar process not spinose. Labial sheath broad (Fig. 15), truncate apically, not bisecting proboscial sheath. Length of antennal sheath 0.56 mm, length of subapical spine 0.08 mm. Thoracic spiracle tapered apically, apex truncate, length 0.20 mm, 2.0 times width. Posterior spines elongate, not divergent apically, length 0.44 mm. Dorsal spines on abdominal segments I–VII in transverse row on posterior third of segment. Abdominal spiracles on segments I–VII.

Type material.—A syntypic series of 3 males of *Ataenogera abdominalis* Kröber is in the Museum für Naturkunde der Humboldt-Universität zu Berlin. A male of this series, herein designated the lectotype, was collected at San Bernardino, Paraguay, in IV, by K. Fiebrig S. V. The holotype female (not male as stated in the description by Bromley 1934) of *Henicomyia brevicornis* Bromley (American Museum of Natural History) was collected at Kartabo, British Guiana, on May 2, 1924. A syntypic series of one male and one female of *Leptocera gracilis* Kröber is in the Zoologische Institut, Halle. The male of this series, herein designated the lectotype, was collected at Paraná, Brazil, in December.

Distribution.—The range of *Ataenogera abdominalis*, a widespread Neotropical species, extends from southern Mexico to Argentina and Uruguay.

Specimens examined (37).—ARGENTINA: **Tucumán:** Amaicha, 16-XI-1966, L. A. Stange, 1M. **Mendoza:** Potrerillos, 6-I-1927, F. and M. Edwards, 1F. **La Rioja:** La Rioja, 1928, 1F. **Catamarca:** 17 km NW Chumbicha, **1143 m**, 25-XII-1971, C. A. Pearson, 1F. BOLIVIA: **Beni:** Río Itenez opposite Costa Marques, Brazil, 1–3-IX-1964, J. K. Bouseman and J. Lussenkop, 1F; 4–6-IX-1964, 1M; 30–31-VIII-1964, 1F; Río Itenez, Pampa de Meio, 11–13-IX-1964, J. K. Bouseman and J. Lussenkop, 1F. BRAZIL: **Paraná:** 1912, 1M 1F; **Pará**, Baker, 1F; **Santa Catarina:** Nova Teutonia, 27°8′, 52°23′, 16-XII-1947, F. Plaumann, 1M; I-1945, 1F; 27°11′, 52°23′, 18-XII-1959, F. Plaumann, 1F. BRITISH GUIANA: Kartabo, 20-V-1924, 1F. COSTA RICA: **Guanacaste:** La Pacifica, 4 km NW Cañas [Las Cañas], 1–9-IV-1974, P. A. Opler, 1M 4F; 29-III-1974, 1F. EL SALVADOR: Quezaltepeque, 2-XI-1977, MEI, 1F. MEXICO: **Morelos:** 11.7 km S Yautepec, 17-VIII-1962, N. L. Marston, 2F; **Puebla:** 4.8 km NW Petlalcingo, 3-IV-1962, F. D. Parker, 1F. PANAMA: **Canal Zone**, Ancon, 4-V-1926, C. T. Greene, 1F; 9-IV-1926, 1F. PARAGUAY: San Bernardino, IV, K. Fiebrig, 1M; 5-IV, 1M; -/-/-, 1M. TRINIDAD: St. Augustine, V-1959, F. D. Barrett, 1F. URUGUAY: **Minas:** Arassuahy, X-1929, Thieman, 1F. VENEZUELA: **Barinitas:** 10 km SE Barinitas, 1-III-1986, R. B. Miller, 1M.

## Genus *Phycus* Walker

*Phycus* Walker (1850: 1): Irwin and Lyneborg (1981: 260); Lyneborg (1978: 212). Type species: *Xylophagus canescens* Walker (1848: 129) by monotypy (= *Xylophagus brunneus* Wiedemann, 1824: 19).

*Caenophanes* Loew (1874: 415): Lyneborg (1978: 212). Type species: *C. insignis* Loew (1874: 415) by monotypy. Preoccupied by *Caenophanes* Foerster (1862: 236).

*Caenophanomyia* Bezzi (1902: 191): Lyneborg (1978: 212). New name for *Caenophanes* Loew (1874: 415).

*Paraphycus* Becker (1923: 62): Lyneborg (1978: 212). Type species: *Phycus nitidus* Wulp (1897: 137) by original designation.

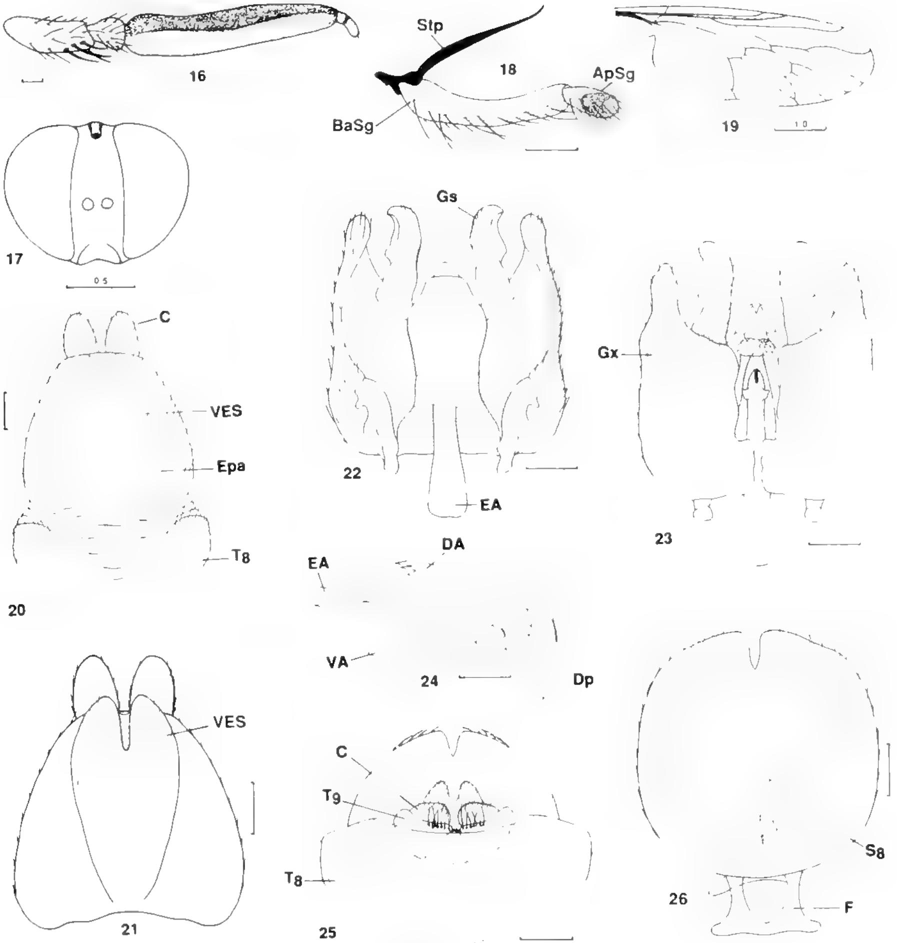
*Caenophaniella* Séguy (1941: 112): Lyneborg (1978: 212). Type species: *C. nigra* Séguy (1941: 112) by original designation.

Moderate-sized, slender flies.

Head.—Frons of both sexes at its narrowest from as wide as to more than twice as wide as ocellar tubercle (Figs. 17, 35), wider in female than in male of same species, with shining black areas and tomentose areas, setae sparse, scanty, or absent; male eyes dichoptic, eye margins only slightly divergent from level of ocellar tubercle toward genae (Figs. 17, 35), facets equal, setae absent; parafacial lacking setae; head slightly to distinctly protruding at antennal level; facial and genal calli absent; antenna (Fig. 16) elongate, length 1.4–1.9 times head depth; scape cylindrical; pedicel subtriangular; flagellum elongate, tapered apically, setae absent, ratio of lengths of flagellum to scape differs greatly among species; flagellar style terminal, two-segmented, with minute terminal spine; clypeus with surface concave, setae absent; maxillary palpus two-segmented (Fig. 18), basal segment cylindrical, apical segment oval or lobate with large, apical sensory pit.

Thorax.—np 1–2, sa 1, pa 1, dc 0–1, sc 1; vittae absent; mesonotal setae short, uniform, erect; prosternum bare in and around central depression; pleural setae very short, sparse. Wing (Fig. 19).—Pterostigma absent; setulae dorsal on $R_1$; subcostal cell and cell $r_1$ elongate, open; veins $R_4$ and $R_5$ subequal; cell $r_4$ large, enclosed apex of wing, 2.2–2.6 times as long as wide at apex; cell $m_3$ usually closed, petiolate; discal cell trunctae basally; m-cu/r-m subequal. Legs.—Fore coxae elongate, sparsely setose, with 3 stiff apical macrosetae; middle coxae bare on posterior surface; femora without setae; tibiae with short setae.

Abdomen.—Slender, especially in male, laterally compressed toward apex; dorsum convex, shining black or reddish brown; setae sparse and short; male and female lack lanceolate setae ventrally. Male terminalia (Figs. 20–24).—Tergite 8 ($T_8$) comparatively wide and deeply to moderately constricted medially. Sternite 8 large and simple. Epandrium (Epa) simple, without posterior incision, may be shorter, equal, or longer in midline than maximum width; cerci (C) free, well sclerotized, extending posteriorly beyond epandrium and ventral epandrial sclerite. Ventral epandrial sclerite, ventral view (VES) large, well sclerotized, setose, extending to anterior margin of epandrium with membranous attachment to dorsal apodeme of aedeagus. Hypandrium absent in New World species. Gonocoxites (Gx) broad, heavily sclerotized; separated ventromedially. Gonostylus (Gs) large, thick, extending slightly beyond apex of gonocoxite. Aedeagus laterally attached by a strongly sclerotized bridge to midsection of paramere; distiphallus (Dp) forms a fine, downwardly directed tube; dorsal apodeme (DA) broad; ventral apodeme (VA) shaped as two elongate extensions; ejaculatory apodeme (EA) large; paramere composed of a distal process, which curves in inward and downward approaching base of gonostylus, and a stout basal apodeme. Female terminalia (Figs. 25, 26).—Tergite 8 ($T_8$) broad, broadly concave along posterior margin. Tergite 9 ($T_9$) subtriangular, separated medially with several strong setae along posterior margin. Tergite 10 bilobed, membranous. Cerci (C) membranous, simple, with scattered setae. Sternite 8 ($S_8$) large, as long as wide, with short median incision on pos-



Figs. 16–26. *Phycus frommeri.*—16. Antenna (*5446*). 17. Head of male, frontal view (*5169*). 18. Maxillary palpus, lateral view (*5446*). 19. Wing, dorsal view (*5169*). 20. Male tergite 8, epandrium, cerci, and ventral epandrial sclerite, dorsal view (*5446*). 21. Male ventral epandrial sclerite, ventral view (*5446*). 22. Male gonocoxites and gonostylus, dorsal view (*5446*). 23. Male gonocoxites and gonostylus, ventral view (*5446*). 24. Male aedeagus, lateral view (*5446*). 25. Female terminalia, dorsal view (*5730*). 26. Female terminalia, ventral view (*5730*). Abbreviations: (ApSg) apical segment; (BaSg) basal segment; (C) cercus; (DA) dorsal apodeme; (Dp) distiphallus; (EA) ejaculatory apodeme; (Epa) epandrium; (F) furca; (Gs) gonostylus; (Gx) gonocoxites; ($S_8$) sternite 8; (Stp) stipes; ($T_8$) tergite 8; ($T_9$) tergite 9; ($T_{10}$) tergite 10; (VA) ventral apodeme; (VES) ventral epandrial sclerite. Scale = 0.1 mm, unless otherwise indicated.

terior margin. Sternite 9 greatly modified, invaginated beneath sternite 8 to form internal furca (F).

Several Old World species of *Phycus* have been observed walking along dead and fallen tree trunks in riverine habitats. The New World species from western North America have been observed walking on rocks under *Washingtonia* palms or other vegetation in desert canyon bottoms (Irwin, personal observation).

## *Phycus frommeri* Webb and Irwin, New Species

Derivation of name: this species is named in honor of Saul I. Frommer, University of

California, Riverside, who collected most of the specimens.

Diagnosis.—*P. frommeri* can be distinguished from *P. frontalis* by the following combination of characteristics: eyes (Fig. 17) separated by a distance greater than the width of the ocellar tubercle; width of frons at level of lateral ocelli greater than 0.5 times width at level of antennal bases; posterolateral extensions of gonocoxites in ventral view (Fig. 23) short, thick.

Description of male holotype (*5169*).—Length (excluding antenna) 6.7 mm.

Head.—Ocellar tubercle black, tomentum light gray; ocellar setae black, short, appressed. Eyes dark brown, separated dorsally by distance greater than width of ocellar tubercle (as in Fig. 17). Frons black, tomentum light gray, converging slightly at vertex (as in Fig. 17), setae black, short, erect, in mediolateral row. Antenna (as in Fig. 16) dark brown, tomentum light gray; length of scape 0.32 mm, 2.3 times width, 2.3 times length of pedicel, setae black, scattered, erect, with several larger macrosetae ventrally; length of pedicel 0.14 mm, 1.0 times width, setae black, short, stiff; length of flagellum 0.78 mm, 4.9 times width, 2.4 times length of scape; length of basal stylomere 0.02 mm, length of apical stylomere 0.10 mm. Parafacial narrow, dark brown, tomentum silver. Genal setae white, elongate. Clypeus brown, tomentum silver. Maxillary palpus (as in Fig. 18) dark brown, tomentum silver; length of basal segment 0.34 mm, 5.4 times width, setae black, elongate; length of apical segment 0.10 mm, 1.7 times width, 0.29 times length of basal segment, setae shorter than those of basal segment. Labellum dark brown, tomentum light gray; setae along ventral margin brown, moderately long. Postocular setae white, fine, abundant ventrally becoming black, stiff, erect toward vertex.

Thorax.—Black, tomentum light silver, setae white, fine, scattered; np 2, sa 1, pa 1, dc 0, sc 1. Postpronotal lobe concolorous with thorax; setae white, fine, scattered. Propleuron, anepisternum, katepisternum, meron dark brown, tomentum silver; anepimeron fuscous, glossy. Pleural setae white to pale yellow, abundant on propleuron, and scattered over anepisternum; absent on remaining pleural sclerites. Scutellum black, tomentum silver; setae white to pale yellow, scattered. Postnotum and laterotergite dark brown to black, tomentum silver; setae on laterotergite white to silver, elongate, abundant. Wing (as in Fig. 19).—Length 5.2 mm, width 1.8 mm, length 2.9 times width. Wing membrane hyaline with apical third pale smoky brown. Halter dark brown, tomentum light gray. Legs.—Coxae dark brown, tomentum silver; femora, tibiae and tarsi dark brown. Coxae with 3 stiff, brown apical setae.

Abdomen.—Dark brown, subshiny; setae dark brown, short, appressed with pale yellow, elongate setae laterally on tergite 1. Male terminalia (as in Figs. 20–24).—Tergite 8 ($T_8$) as wide as epandrium, deeply concave medially. Epandrium (Epa) as long as wide medially; cerci broad (C), rounded apically; ventral epandrial sclerite (VES), ventral view, deeply incised medially on apical margin. Gonocoxites (Gx) in dorsal view broad, heavily sclerotized; in ventral view separated medially. Gonostylus (Gs) large, thick, extending slightly beyond apex of gonocoxites.

Variation in males (N = 10).—Body length (excluding antenna) 5.7–7.3, 6.6 mm. Head depth 0.76–0.84, 0.81 mm. Length of antenna 1.5–1.9, 1.7 times head depth; length of scape 0.30–0.40, 0.34 mm, 2.3–3.0, 2.5 times width, 2.3– 2.9, 2.5 length of pedicel; length of pedicel 0.12–0.14, 0.13 mm, 0.8–1.2, 1.0 times width; length of flagellum 0.76–0.92, 0.83 mm, 4.7–5.8, 5.0 times width, 1.7–2.5, 2.0 times length of scape; length of basal stylomere 0.02 mm, length of apical stylomere 0.10 mm. Length of basal segment of maxillary palpus 0.34–0.40, 0.38 mm, 4.5–5.7, 5.0 times width; length of apical segment 0.10–0.14, 0.12 m, 1.2–1.8, 1.5 times width, 0.26–0.39, 0.31 times length of basal segment. Wing length 4.5–6.8, 4.9 mm, 2.8–3.0, 2.9 times width. Variation in the color pattern was found in one specimen (*5329*) where the anepisternum, anepimeron, meron, metepleuron, middle and hind coxae, and entire abdomen were pale brown and subshiny.

Female.—Similar to male with frontal setae scattered.

Female terminalia (Figs. 25, 26).—Characteristics given in description of genus.

Variation in females (N = 10).—Body length (excluding antenna) 8.2–9.6, 8.8 mm. Head depth 0.94–0.96, 0.95 mm. Length of antenna 1.4–1.6, 1.5 head depth; length of scape 0.40–0.46, 0.43 mm, 2.5–2.9, 2.7 times width, 2.0–2.9, 2.4 times length of pedicel; length of pedicel 0.16–0.20, 0.18 mm, 1.0–1.3, 1.2 times width; length of flagellum 0.68–0.80, 0.74 mm, 4.3–5.0, 4.6 times width, 1.1–1.3, 1.2 times length of scape; length of basal stylomere 0.02 mm, length of apical stylomere 0.10 mm. Length of basal segment of maxillary palpus 0.42–0.46, 0.45 mm, 5.3–5.8, 5.7 times width; length of apical segment 0.14 mm, 1.8 times width, 3.0–3.3, 3.2 times length of basal segment. Wing length 6.2–6.5, 6.4 mm, length 2.0–2.2, 2.0 times width.

Ecology.—The majority of specimens were collected in Malaise traps situated in canyon washes. Individual specimens were collected on rocks and under *Washingtonia* palms, with a single male collected on *Eriogonum fasciculatum polifolium (5602)*. In the collections examined, a distinct difference was noted in the pattern between timing of adults collected in Mexico and in California. In Mexico, 92% of the adults were collected between 12 March and 5 May, while 8% were collected between 23 August and 8 November; 77% of the adults were collected during April. In California, adults were collected between 25 April and 29 July; the majority of specimens were collected between early May and mid June. Overall, males (405) were collected 1.7 times more frequently than females (243). Figure 27 shows the variation in flight periodicity at Deep Canyon, Riverside County, California, during 1969 and 1970. Two female larvae of *Phycus frommeri* were collected by R. B. Miller and L. A. Stange, one (*5620*) from under small conglomerates of fine soil at the base of a tree in a shaded gully and the other (*5619*) in loose soil under boulders, both in the state of Colima, Mexico. These were reared to adults in our laboratory.

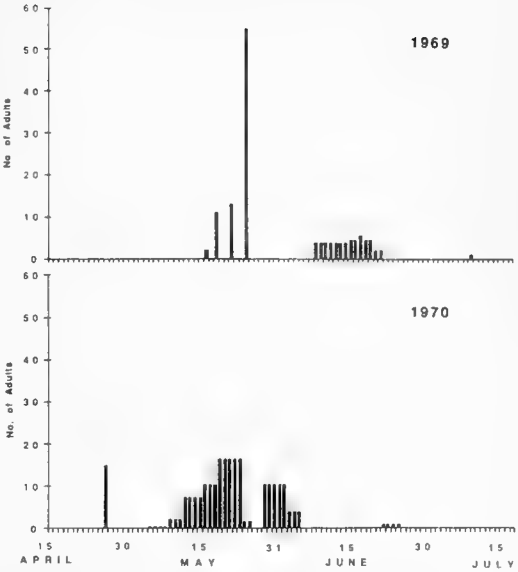
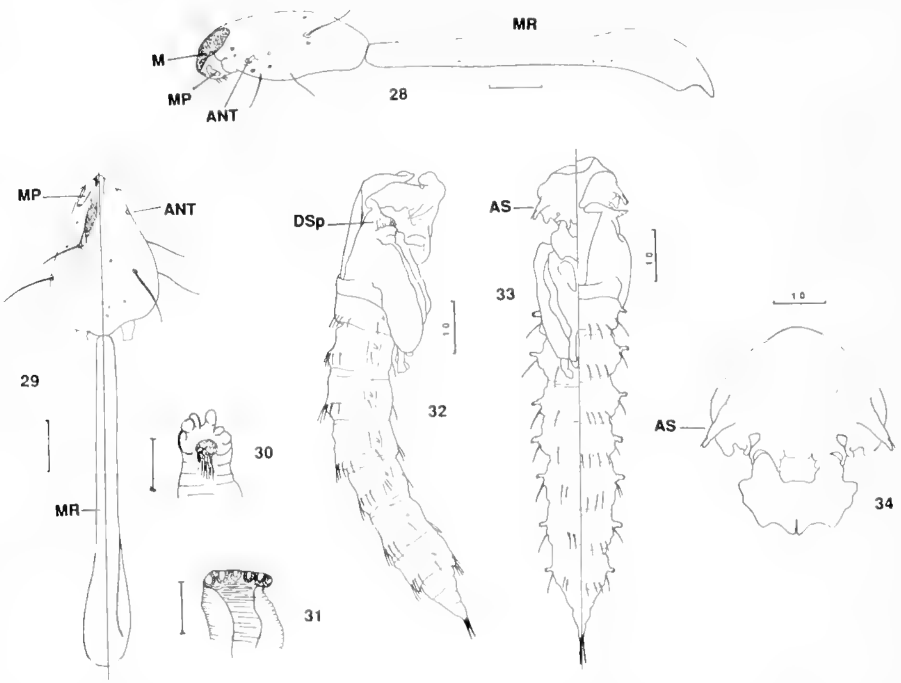


Fig. 27. *Phycus frommeri.*—Flight periodicity in Deep Canyon, Riverside County, California, in 1969 and 1970 as measured in a single Malaise trap.

Larva.—Head (Figs. 28–31) length 0.42 mm; metacephalic rod (MR) elongate, posterior third clavate, length 0.86 mm, 2.0 times length of head. Prothoracic spiracle (Fig. 30). Posterior spiracle (Fig. 31).

Pupa (Figs. 32–34).—Length 7.7–9.1 mm (N = 2), width 1.7–2.0 mm. Alar process not spinose. Labial sheath broad, truncate apically, not bisecting proboscial sheath. Length of antennal sheath 0.54 mm, length of subapical spine 0.14 mm. Length of thoracic spiracle 0.38 mm, tapered apically, apex truncate. Posterior spines elongate, not divergent apically, length 0.50 mm. Dorsal spines on abdominal segments I–VII and



Figs. 28–34. *Phycus frommeri* larva and pupa exuvia (*5619*)—28. Larval head capsule, lateral view. 29. Larval head capsule, dorsal view (right), ventral view (left). 30. Prothoracic spiracle of larva, lateral view. 31. Posterior spiracle of larva, posterior view. 32. Pupal exuvium, lateral view. 33. Pupal exuvium, dorsal view (right), ventral view (left). 34. Frontal plate of pupal exuvium. Abbreviations: (ANT) antenna; (AS) antennal sheath; (DSp) dorsal spiracle; (M) mandible; (MP) maxillary palpus; (MR) metacephalic rod. Scale = 0.1 mm, unless otherwise stated.

ventral spines on segments II–VII fine, not fused basally. Abdominal spiracles on segments I–VII moderately thick, tubular.

Distribution.—The range of *Phycus frommeri* extends from southern California to the southern tip of Baja California Sur and along the northwestern border of Sonora, Mexico southward to the state of Colima.

Specimens examined (661).—Holotype: male, Irwin specimen number *5169*, CAS type no. 15741 (on permanent loan to the California Academy of Sciences from the University of California, Riverside); California, Riverside County, P. L. Boyd Desert Research Center, 3.5 mi S Palm Desert, marker #57, 18–23-V-1970, S. I. Frommer, in a Malaise trap. Paratypes as follows: UNITED STATES—CALIFORNIA: **Riverside Co.:** P. L. Boyd Desert Deep Canyon Research Center, 5.6 km S Palm Desert, 6–13-VI-1969, SIF, 14 M 13 F; 6–8-V-1970, SIF, 1 M; 15–18-V-1970, SIF, 23 M 5 F; 18–23-V-1970, SIF, 50 M 20 F; 27-V-1-VI-1970, SIF, 35 M 15 F; 13–18-VI-1969, SIF RMW, 13 M 10 F; 18–19-VI-1969, SIF RMW, 2 M 2 F; 19–20-VI-1969, SIF RMW, 1 M 1 F; 20–24-VI-1969, SIF RMW, 4 M 1 F; 8-VII-1969, SIF RMW, 1 F; 4–6-V-1970, SIF RMW, 1 F; 26-IV-3-V-1970, SIF RMW, 1 M; 8–12-V-1970, SIF RMW, 7 M 2 F; 11–13-V-1970, SIF RMW, 5 M; 13–15-V-1970, SIF RMW, 8 M 2 F; 23–25-V-1970, SIF RMW, 16 M 18 F; 25–26-V-1970, SIF RMW, 25 M 17 F; 1–4-VI-1970, SIF RMW, 8 M 4 F; 21–29-V-1973, A. B. Tabet, 2 M; 5–13-VI-1973, A. B. Tabet, 7 M 4 F; 24-V-1969, MEI SIF, 44 M 12 F; 8-VI-1965, MEI, 1 M 1 F; 16-V-1969, MEI, 1 M 1 F; 18-V-1969, MEI, 8 M 3 F; 21-V-1969, MEI, 11 M 2 F; 13–20-VI-1973, A. B. Tabet, 5

M; 21-VI-1962, EIS, 1 F; 19-V-1964, MEI, 1 M; 11-VI-1965, MEI, 1 F; 9–16-V-1973, A. B. Tabet, 1 M; 5 mi W Sage, 3-VII-1963, P. D. Hurd, 1 F; 2-VII-1963, E. I. Schlinger, 1 F; Idyllwild, 27-VI-1956, M. S. Wasbauer, 1 M; Carrizo Creek, 30-VI-1964, E. I. Schlinger, 1 F; Massacre Canyon, 300 yds up from Highway 79, 29-VII-1964, MEI, 1 F. **San Diego Co.:** Culp Canyon, 12-VI-1958, E. I. Schlinger, 12 F; Borego, 1-V-1946, J. S. Perry, 1 M; 9.7 km E San Diego, 26-VI-1963, H. L. Griffin, 1 F, R. L. Langston, 1 F; San Vicente Res., 229 m, 16-VI-1965, MEI, 1 F. MEXICO—**Baja California Sur:** 100 km NW La Paz, Arroyo Guadalupe, **107 m**, 20-IV-1968, MEI, 2 M; 14.5 km S Loreto, 17-IV-1968, MEI, 12 M 1 F; 4.8 km E San Ignacio, **171 m**, 14-IV-1968, MEI, 1 F; 3 km E La Burrera, **515 m**, 2–3-IX-1977, J. L. Fisher and R. L. Westcott, 1 M; 2.5 km E La Burrera, **549 m**, E. M. and J. L. Fisher, 1 M; 6.4 km NW Don Pancho, 1-VIII-1964, MEI, 1 F; Las Barracas, ca. 30 km E Santiago, 25–31-III-1982, P. DeBach, 1 M; 1–6-IV-1982, P. DeBach, 2 M 1F; 13–18-IV-1982, P. DeBach, 1 F; 19–24-IV-1982, P. DeBach, 1 M; 25–30-IV-1982, P. DeBach, 1 M; 7–12-V-1982, P. DeBach, 4 M 2 F. **Sinaloa:** 86.9 km S Culiacan, **164.6 m**, 23-IV-1969, MEI, 1 M; "Las Escondidas," 106.2 km N Mazatlán, **137 m**, 22-IV-1968, MEI, 16 M 25 F. **Colima:** Los Tempanes, 12-III-1985, R. B. Miller and L. A. Stange, 1 F reared from larva; Río Salado, 7 km S Colima, 14-III-1985, 1 F reared from larva.

### *Phycus frontalis* Webb and Irwin, New Species

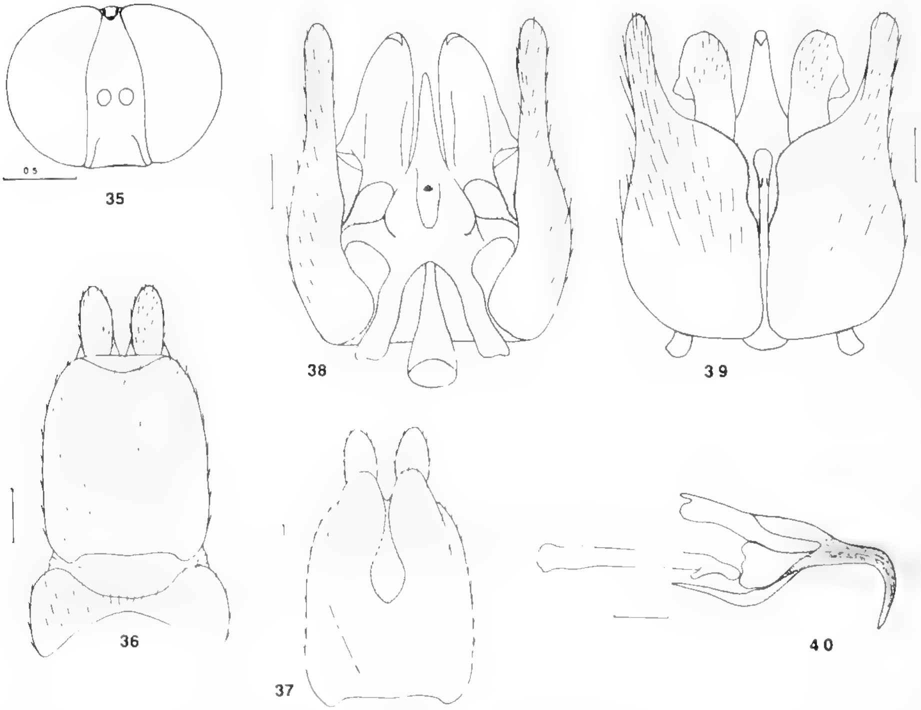
Derivation of name: *front* (Latin) = brow; *alis* (Latin) = pertaining to.

Diagnosis.—*P. frontalis* can be distinguished from *P. frommeri* by the following combination of characteristics: eyes separated dorsally only by width of ocellar tubercle (Fig. 35); frons distinctly convergent towards vertex (Fig. 35), width at level of lateral ocelli less than 0.5 times width at level of antennal bases; posterolateral extensions of gonocoxites in ventral view narrow, attenuate (Fig. 39).

Description of male holotype (*5179*).—Length (excluding antenna) 6.8 mm.

Head.—Ocellar tubercle fuscous, tomentum light gray; ocellar setae fuscous, moderately long, scattered. Eyes fuscous, separated medially by distance equal to width of ocellar tubercle (Fig. 35). Frons fuscous, tomentum light gray, dense silver around antennal bases; width at level of ocellar tubercle 0.40 times width at level of antennal bases (Fig. 35); setae pale yellow, moderately long, in mediolateral row; callus absent. Antenna as in *P. frommeri* (Fig. 16), fuscous, tomentum light gray; scape, length 0.34 mm, 2.8 times width, 2.8 times length of pedicel, setae fuscous, short, subappressed with several large, stiff macrosetae ventrally; pedicel, length 0.12 mm, 1.0 times width, setae fuscous, short, suberect; flagellum, length 0.82 mm, 4.6 times width, 2.4 times length of scape; basal stylomere, length 0.04 mm, apical stylomere, length 0.10 mm, apical spine minute. Parafacial fuscous, tomentum dense silver. Genal setae white to silver, elongate, abundant. Clypeus fuscous, tomentum dense silver. Maxillary palpus as in *P. frommeri* (Fig. 18), dark brown, tomentum light gray; length of basal segment 0.34 mm, 4.3 times width, setae dark brown, moderately long, erect, on ventral surface; length of apical segment 0.14 mm, 0.41 times length of basal segment, setae sparse. Labellum dark brown, tomentum light gray; setae brown, moderately long, scattered. Postocular setae white to silver, elongate, abundant on ventral half, with numerous black, stiff setae dorsally.

Thorax.—Fuscous, tomentum light gray; setae white to silver, moderately long, scattered; np 2, sa 1, pa 1, dc 0, sc 1. Postpronotal lobe concolorous with thorax; setae white to silver, moderately long, scattered. Propleuron, anepisternum, katepisternum, meron fuscous, tomentum silver, anepimeron glossy. Pleural setae white to silver,



Figs. 35–40. *Phycus frontalis* (*5180*). 35. Head of male, frontal view. 36. Male epandrium, cerci, and ventral epandrial plate, dorsal view. 37. Male ventral epandrial plate, ventral view. 38. Male gonocoxites and gonostylus, dorsal view. 39. Male gonocoxites and gonostylus, ventral view. 40. Male aedeagus, lateral view. Scale = 0.1 mm, unless otherwise stated.

elongate, abundant on propleuron, scattered on anepisternum, on ventral third of katepisternum, absent on anepimeron and meron. Scutellum fuscous, tomentum light gray; setae pale yellow, moderately long, scattered. Postnotum and laterotergite fuscous, tomentum light gray; setae on laterotergite white to silver, elongate, abundant. Wing as in *P. frommeri* (Fig. 19).—Length 5.0 mm, width 1.8 mm, length 2.8 times width. Halter fuscous, tomentum light gray. Legs.—Dark brown, coxae with tomentum silver; anterior tubercle on hind coxa dark brown, apical half pale.

Abdomen.—Fuscous, subshiny; setae fuscous, short, appressed, mixed with pale yellow, elongate, suberect setae. Male Terminalia (as in Figs. 36–40).—Tergite 8 similar to *P. frommeri*. Epandrium rectangular, 1.25 times longer than wide, posterior margin truncate; cerci lobate; ventral epandrial sclerite, ventral view, with dark brown setae. Gonocoxites in ventral view with posterolateral extension narrow, attenuate.

Variation in males (N = 2).—Body length (excluding antenna) 6.8–6.9, 6.8 mm. Head depth 0.78–0.92, 0.85 mm. Antenna, length 1.1–1.5, 1.3 times head depth; scape, length 0.32–0.34, 0.33 mm, 2.3–2.8, 2.6 times width, 2.8–3.2, 3.0 times length of pedicel; pedicel, length 0.10–0.12, 0.11 mm. Maxillary palpus, basal segment length 0.30–0.34, 0.32 mm, 3.8–4.3, 4.1 times width; apical segment length 0.10–0.14, 0.12 mm, 1.3–1.8, 1.6 times width, 0.33–0.41, 0.37 times length of basal segment. Wing length 5.0–5.5, 5.3 mm, 2.8–3.1, 3.0 times width.

Female.—Similar to male. Female Terminalia.—As in *P. frommeri* (Figs. 25, 26).

Variation in females (N = 2).—Body length (excluding antenna) 7.4 mm. Head depth 1.10–1.18, 1.14 mm. Antenna length

1.4 times head depth; scape, length 0.41–0.44, 0.43 mm, 2.6–2.8, 2.7 times width, 2.4–3.0, 2.7 times length of pedicel; pedicel, length 0.14–0.18, 0.16 mm, 0.8–1.0, 0.9 times width; flagellum, length 0.84 mm, 4.7 times width, 2.0 times length of scape; basal stylomere length 0.04 mm, apical stylomere length 0.10 mm. Maxillary palpus, basal segment length 0.40–0.52, 0.46 mm, 5.0–5.2, 5.1 times width; apical segment length 0.16–0.20, 0.18 mm, 1.4–2.0, 1.6 times width; 0.38–0.40, 0.39 times length of basal segment. Wing length 6.7–7.7, 7.2 mm, 3.0–3.1, 3.15 times width.

Distribution.—The range of *Phycus frontalis* extends from Yucatán, Mexico to Costa Rica.

Specimens examined (4).—Holotype: male, Irwin specimen number *5179* (AMNH), Mexico, **Yucatán**, Chichén Itzá, VI-29. Paratypes as follows: MEXICO—**Yucatán:** Chichén Itzá, VI-1929, 1 M 1 F. COSTA RICA—La Suiza, 1924, P. Schild, 1 F.

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# A MID-SUMMER COMPARISON OF SIZES AND GROWTH RATES AMONG NYMPHS OF THREE SYMPATRIC MANTIDS (MANTODEA: MANTIDAE) IN TWO OLD-FIELD HABITATS

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*Abstract.*—We compared three species of mantid nymphs in two field habitats (sites CHRY and AG), in two censuses during mid-summer 1986. *Tenodera sinensis* (Saussure) nymphs exhibited no difference between sites, either in size of nymphs, or in rate of maturation. Both *T. angustipennis* and *M. religiosa* were significantly larger in site CHRY than in site AG in August, although no such difference had been evident in July. More individuals of these two species had also matured in CHRY than in AG by the August census. These data suggest that *T. angustipennis* and *M. religiosa* were more food limited at site AG than at site CHRY during the time just prior to maturation. These results are consistent with the hypothesis that *Tenodera sinensis* is more of a habitat generalist than the other two species.

*Key Words:* Mantodea, Mantidae, *Tenodera, Mantis,* food limitation, sympatry, predators

Mantids are generalist predators subject to food limitation which varies in importance during a growing season, as well as between habitats and years (Matsura et al. 1975, Hurd et al. 1978, Hurd and Eisenberg 1984, Eisenberg et al. 1981). Food limitations on newly hatched nymphs can retard development and decrease size of the imago, which in turn reduces fecundity (Eisenberg et al. 1981, Matsura and Marooka 1983, Hurd and Eisenberg 1984, Hurd and Rathet 1986). Therefore, comparing sizes of mantids collected at the same time from different habitats could provide a relative measure of the differences between habitats in terms of food limitation and fitness for a given species. We can then ask the same question of any number of mantid species found together in the same habitat to discern whether the resource level in a given field is qualitatively the same for each species.

Most ecological work on mantids has concentrated on a single species in a single habitat during either the first month of life or adulthood. Rathet and Hurd (1983) studied growth rates and habitat placement within a single field site, of nymphs of three species which commonly occur together in old fields in northern Delaware: *Tenodera sinensis* (Saussure), *T. angustipennis* (Saussure), *Mantis religiosa* (Linnaeus). These three morphologically similar species hatch at different times, differ in body size (*T. sinensis* > *T. angustipennis* > *M. religiosa*), and/or inhabit different levels of foliage within a field. These niche differences suggest to us that there may be differences in resource utilization among these species. In an exploratory study designed to detect both

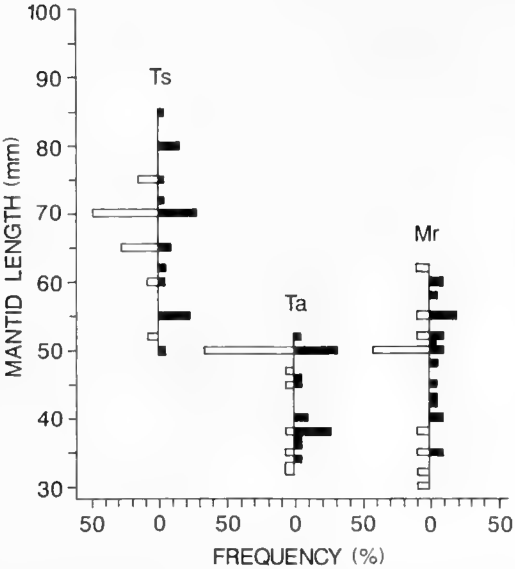

Fig. 1. Sizes of mantid nymphs in two habitats on 19 July 1986. Open bars represent frequency of nymphs of various sizes found at site AG; shaded bars are for site CHRY. Ts = *Tenodera sinensis*, Ta = *T. angustipennis*, Mr = *Mantis religiosa*. One-way ANOVA: F = 24.945; df = 5, 72; $P < 0.001$. LSD comparisons indicate *T. sinensis* is significantly larger than the other two species; no differences between sites.

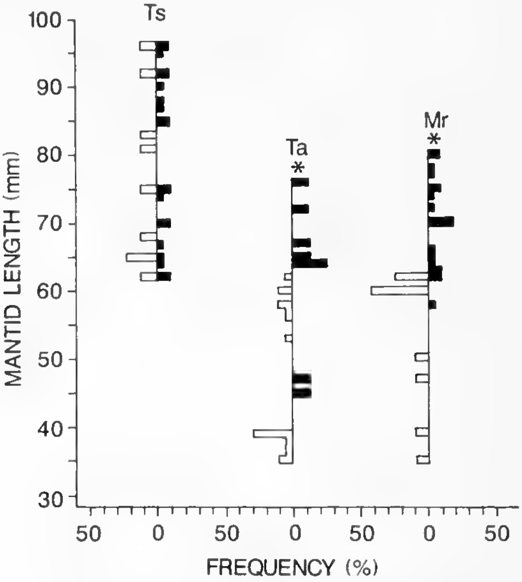

Fig. 2. Sizes of mantid nymphs in two habitats on 13 August 1986. Open bars represent frequency of nymphs of various sizes found at site AG; shaded bars are for site CHRY. Ts = *Tenodera sinensis*, Ta = *T. angustipennis*, Mr = *Mantis religiosa*. One-way ANOVA: F = 25.714; df = 5, 84; $P < 0.001$. LSD comparisons indicate *T. sinensis* is significantly larger than the other two species; site differences indicated by asterisks.

site and interspecific differences, we compared sizes and growth rates of these three mantid species in two old fields during the last nymphal stages.

## Materials and Methods

The two old-field habitats in our study are in Newark, New Castle County, Delaware. They are approximately 3 km apart and have different vegetation. One field, site AG, is located on the experimental farm of the School of Agriculture, University of Delaware, and is dominated by a dense ground cover of timothy (*Phleum pratense*) and Canada bluegrass (*Poa compressa*) with patches of goldenrod (*Solidago* spp.) and thistle (*Cirsium* spp.). The other field, site CHRY, is adjacent to the Chrysler plant in Newark, and is dominated by goldenrod with a ground cover of grasses, chiefly timothy.

We censused mantids in both habitats on 19 July and 13 August 1986, which bracketed the last month of nymphal life for these species. Individuals were hand caught, identified, measured for length (front of head to tip of abdomen), and then released at the point of capture. Sex was recorded for those mantids which had matured by the second census. Lengths were compared among species and habitats on each census date with one-way ANOVA and least signifcant difference *post hoc* comparison using Statgraphics (STSC, version 2.1).

## Results and Discussion

*Tenodera sinensis* nymphs were larger than the other two species at both sites in July (one-way ANOVA, F = 24.945; df = 5, 72; $P < 0.001$), and *M. religiosa* was not significantly different in size from *T. angustipennis* (Fig. 1). This interspecific difference was expected from earlier results

Table 1. Numbers of individuals, % adult and adult sex ratio for three mantid species in two habitats (AG and CHRY) in July and August of 1986. Mr = *Mantis religiosa,* Ts = *Tenodera sinensis,* Ta = *T. angustipennis.*

| Species | Site | July *N* | August *N* | % Adult | M:F |
|---|---|---|---|---|---|
| *M. religiosa* | AG | 12 | 12 | 75 | 7:2 |
| | CHRY | 20 | 20 | 100 | 10:10 |
| *T. angustipennis* | AG | 20 | 19 | 0 | |
| | CHRY | 23 | 8 | 25 | 2:0 |
| *T. sinensis* | AG | 15 | 9 | 56 | 1:4 |
| | CHRY | 26 | 22 | 59 | 7:6 |

(Rathet and Hurd 1983) and published size differences for adults (Gurney 1950, Helfer 1963). There were no differences in size between sites for any species at this time. Apparently, then, the sites did not differ in food limitation from egg hatch until mid-July. There were no adults of any species present in either field on 19 July.

The August census revealed a number of differences which were not apparent in July (Fig. 2). *Tenodera sinensis* was still significantly larger than the other two species at both sites (one-way ANOVA, $F = 25.714$; $df = 5, 84$; $P < 0.001$), and did not exhibit a difference between sites in size or percentage of adults (Table 1). However, both *M. religiosa* and *T. angustipennis* were significantly larger at site CHRY than at site AG (Fig. 2), and more had matured at site CHRY (Table 1). The size differences could not be attributed solely to a greater number of adults at CHRY because even the largest adults at AG were smaller than the largest adults at CHRY for both species. These data suggest that there was greater food limitation during the intervening month at site AG for these two species than at site CHRY. Some adult *M. religiosa* at CHRY were considerably larger (75–80 mm) than previously published records for this species (about 65 mm) (Gurney 1950, Helfer 1963). The sizes of the other two species (Fig. 2) were consistent with the literature.

Eisenberg et al. (1981) hypothesized that mantids could rely on insects which forage on late summer flowers (e.g. goldenrod) for a major portion of their prey when insect biomass declines in the rest of the field. Hurd (1989) found that adult female *T. sinensis* on flowers gained significantly more weight and deposited oothecae with more eggs (i.e. had greater fitness) than those on plants not in flower. We have found mostly *T. sinensis* on these flowers, which may explain why they apparently were not as food limited at site AG as the other two species. Thus, while all three species might rely on the same prey early in the season, *M. religiosa* and *T. angustipennis* could be better indicators of habitat quality in terms of resident arthropod prey availability than *T. sinensis* late in the season. A detailed examination of the diets of these species in the field is needed to test these ideas.

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## NOTE

# *Ixodes downsi* (Acari: Ixodidae) from Peru

*Ixodes downsi* Kohls was originally described from Aripo Cave, Trinidad, on the basis of a male, female, and three nymphs found on the wall of the cave, and one larva found on a bat, *Anoura g. geoffroyi* Gray in the cave (Kohls 1957. Proc. Entomol. Soc. Wash. 59: 257–264). On the basis of this scant information, Kohls (op. cit.) speculated that it might be a bat tick although he noted that oil birds, *Steatornis caripensis* Humboldt, nested in the cave and a large rat was also seen (in the cave). *I. downsi* has not been recorded since the original description.

We report a second locality for the species at a considerable distance from the type locality. An engorged female was collected from the throat of a young, fully feathered *S. caripensis* found on the floor of a cave near Tingo María, Department Huanuco, Peru, on 11 February 1975 by Baker. Bats were heard in the cave but none were seen and several unidentified parrots flew from the cave. This locality is approximately 2600 km southwest of the type locality, on the opposite side of South America. The finding of a specimen on an oil bird only confuses the issue as to whether *I. downsi* is a bat tick or a bird tick. There are no known species of *Ixodes* commonly found on both birds and bats, and additional collecting from hosts will be necessary before the true host relationships can be ascertained.

The length and width measurements of the engorged female from Peru, compared with those of the unengorged allotype female in parentheses, were 7.22 (2.53) mm and 4.07 (1.87) mm, respectively. In all other respects the Peruvian specimen agrees with the original description.

The specimen will be deposited in the Florida State Collection of Arthropods, Florida Department of Agriculture and Consumer Services, Gainesville, Florida.

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# TEMPORAL DISTRIBUTION OF HATCHING TIMES IN THREE SYMPATRIC MANTIDS (MANTODEA: MANTIDAE) WITH IMPLICATIONS FOR NICHE SEPARATION AND COEXISTENCE

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*Abstract.*—Mantids are members of a guild of generalist predators in arthropod communities. Three species commonly coexist in old fields: *Tenodera sinensis* Saussure, *T. angustipennis* Saussure, and *Mantis religiosa* Linnaeus. Egg hatch occurs early in the spring, producing high predator density when prey are in short supply. First instar nymphs of the two *Tenodera* species, which are most similar in size and occupy the same vegetational stratum in the field, are most divergent in timing of egg hatch. Nymphs of *T. sinensis* hatch first, and enter the second instar as *T. angustipennis* are beginning to hatch. The timing of egg hatch for *Mantis religiosa,* which is much smaller than the other two and occupies a different portion of the vegetation, is intermediate. Therefore nymphs of the three species are not the same body size at the same time; body size determines size of prey which can be captured most efficiently. We suggest that the temporal disparity in egg hatch may be one mechanism for coexistence among these species by reducing niche overlap when resources are critically limiting.

*Key Words:* Mantodea, Mantidae, *Tenodera, Mantis,* bitrophic niche, predators, sympatry

Praying mantids (Mantodea: Mantidae) are members of a guild (*sensu* Root 1967) of generalist predators which inhabit arthropod communities. This guild includes other taxa, notably spiders, and all members have in common a bitrophic niche; they occupy both the third and fourth trophic levels by virtue of feeding on other predators as well as on herbivores. Thus, the relationship among guild members is complicated by the potential for both interspecific competition and mutual predation. Added to this is the propensity for cannibalism in some groups. Therefore, interspecific coexistence in this guild, especially among very similar species, may depend upon factors which mitigate a variety of antagonistic interactions.

Three similar species of mantids commonly co-occur in northern Delaware. *Tenodera sinensis* Saussure, the largest of the three, was originally introduced from the orient near Philadelphia, Pennsylvania, in 1896 (Laurent 1898), and has occurred in Delaware at least since the 1930s (Jones 1933). Its congener, *T. angustipennis* Saussure, was found in Maryland in 1926 (Gurney 1950), and had become established in Delaware by 1930 (Jones 1933). *Mantis religiosa* Linnaeus, the smallest of the three, was introduced into the northeastern United States in 1899 (Gurney 1950); its duration of residence in Delaware is uncertain (Rathet and Hurd 1983). All three species are sympatric in Asia (Jing-jin et al. 1981).

We have been studying various populations of mantids, especially *T. sinensis,* in northern Delaware over the past decade (Eisenberg and Hurd 1977, Hurd et al. 1978, Eisenberg et al. 1981, Rathet and Hurd 1983, Hurd and Eisenberg 1984a, b, Hurd 1985, Hurd and Rathet 1986, Hurd 1988). We have observed that all three species can be found in the same general habitat: successional old fields. Emergence from oothecae takes place in early spring when arthropod biomass is very low. In fact, mantid biomass at egg hatch is apt to be much greater than biomass of all other arthropods combined, so nymphs are likely to be severely food limited (Hurd and Eisenberg 1984a, b). It is therefore reasonable to ask: how do the niches of these similar predators differ to allow them to coexist in a limited environment? Rathet and Hurd (1983) found that both *Tenodera* species occupy the same vegetational stratum (30–60 cm foliage height), whereas *M. religiosa* is generally found lower in the vegetation (5–25 cm). Therefore, *M. religiosa* may escape predation from the two larger species, although this does not rule out interspecific competition. Rathet and Hurd (1983) also found that appearance of first instar nymphs in the field was not simultaneous among the three species, and that as a consequence there was a consistent interspecific size difference throughout the season. Mantid nymphs of different sizes have different optimal prey sizes based upon capture efficiency (Bartley 1983). In the present study we ask whether there is an intrinsic difference in timing of egg hatch which could be another mechanism which reduces niche overlap in this guild of generalist predators.

## MATERIALS AND METHODS

We collected oothecae of *T. sinensis*, *T. angustipennis*, and *M. religiosa* from two old fields in Newark, New Castle County, Delaware, on 10 February 1986. The collection sites are approximately 3 km apart, and represent somewhat different vegetational assemblages. One field is located on the experimental farm property of the School of Agriculture, University of Delaware (= site AG), and dominated by a dense ground cover of timothy (*Phleum pratense*) and blue-stemmed grass (*Poa compressa*) with patches of goldenrod (*Solidago* spp.) and thistle (*Cirsium canadensis*). The other site is adjacent to the Chrysler plant in Newark (= site CHRY), and is dominated by goldenrod with a sparse ground cover of grasses, chiefly timothy.

Twelve oothecae of each mantid species from each of the two field sites were returned to the laboratory and immediately placed in separate containers and incubated at 25°C and ambient light. When eggs hatched, newly emerged nymphs were removed from the containers and killed by freezing, after which they were counted. A random sample of 20–30 nymphs from each group was measured for body length (tip of abdomen to front of head).

## RESULTS

*Tenodera sinensis* began hatching after 18 days of incubation, and hatching continued for 11 days from oothecae collected from both sites, with a few nymphs emerging from AG oothecae as late as day 33 (Fig. 1). The pattern of hatching was sporadic with no clear difference between field sites. In only two cases did nymphs emerge on two or more consecutive days from the same ootheca, which is consistent with results from Eisenberg and Hurd (1977). Mean size of nymphs from site CHRY (9.7 mm, SD = 0.37) was somewhat larger than from site AG (9.4 mm, SD = 0.40) ($t = -2.84$, df = 48, $P < 0.01$).

*Tenodera angustipennis* did not start hatching until *T. sinensis* had finished, and duration of hatch was six days (Fig. 1). The pattern of hatching was nearly identical for eggs from both sites. Only one ootheca exhibited hatching on two consecutive days. Mean body length of nymphs (8.9 mm, SD = 0.20) was not different between sites.

*Mantis religiosa* was the only one of the three species to exhibit a marked site difference in hatching pattern (Fig. 1). Hatching time was intermediate, and overlapped with both *Tenodera* species. Unlike *Tenodera* spp., all but one ootheca produced nymphs on consecutive days, as many as five days in a row. As with *T. sinensis*, nymphs from site CHRY were larger (6.1 mm, SD = 0.31) than nymphs from site AG (mean = 5.8 mm, SD = 0.20) (t = −3.78, df = 58, $P < 0.001$).

## Discussion

We found that under identical laboratory conditions of a "common garden" experiment, eggs of *T. sinensis* hatch before those of the other two species. This is in agreement with field observations of first appearance of nymphs (Rathet and Hurd 1983), and indicates an intrinsic difference between species. Matsura (pers. comm.) has also observed that *T. sinensis* hatches before *T. angustipennis* in Japanese fields.

A potential significance of this phenological difference is a reduction in overlap among species with regard to optimal prey size (Bartley 1983), which could reduce competition for limited food early in the growing season: by the time *T. angustipennis* and *M. religiosa* begin to hatch, the earliest *T. sinensis* nymphs would be entering the second instar (Hurd and Eisenberg 1984a, Hurd and Rathet 1986). This is likely to be more important for the two *Tenodera* species, since they are similar in size at emergence and occupy the same vegetational stratum, than for *M. religiosa* which occupies a different portion of the vegetation (Rathet and Hurd 1983) and is much smaller. The fact that the timing of egg hatch in *M. religiosa* overlaps the other two species may be further indication that interaction between these genera is less important than between species of *Tenodera*. Of course the question remains as to whether the temporal differences in hatching arose from historic interspecific competition, or represent a fortuitous preadaptation to living in the same habitat.

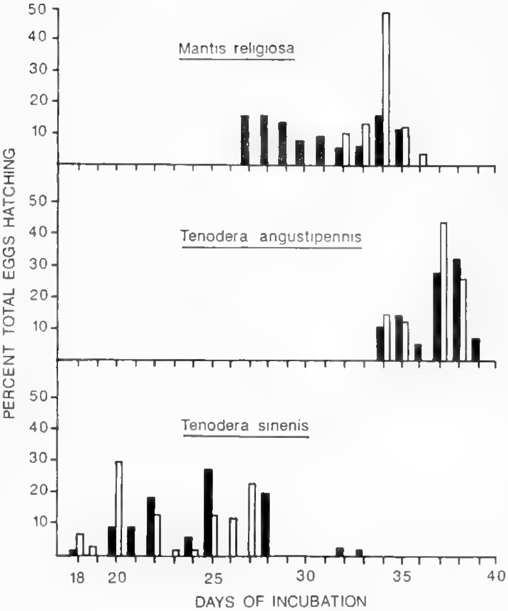

Fig. 1. Timing and pattern of egg hatch, as a percent of total eggs hatching for each species from oothecae collected at two field sites: AG = shaded bars, CHRY = open bars.

In instances where food is severely limiting, the size difference between second instar nymphs of *T. sinensis* and first instar *T. angustipennis* would confer an additional benefit on the former species, that of being able to use its congener (and later-hatching conspecifics) as a food source. We have observed in the laboratory that intra-instar predation between and within these congeneric nymphs is relatively uncommon, as is the case with *M. religiosa* according to Roeder (1936). However, we have also observed that the difference in size between successive instars is sufficiently great to provoke much cannibalism and interspecific predation (Hurd 1988). This may help to explain why we have never found *T. angustipennis* to be abundant in fields wherein *T. sinensis* was well-established.

We found two indications of differences between field sites: the difference in hatching patterns for *M. religiosa*, and the larger nymphs at site CHRY for both this species and *T. sinensis*. The difference in nymph size may well be an indication of differences in feeding conditions for adult mantids during the previous season. Eisenberg et al. (1981) found that food limitation among adults plays an important role in biomass of oothecae; egg size may also be affected. This would indicate that adults of these two species were more food limited at site AG than at site CHRY. We are currently testing this.

Another possibility is that the size differences represent ecotypes for one or both species. This remains to be tested, as does the question of what is the gain in fitness by hatching at a larger size? One possibility is a decline in time of development, although *T. sinensis,* at least, is flexible in this regard (Hurd and Rathet 1986). We cannot as yet offer a satisfactory explanation for the difference in hatching patterns for *M. religiosa* (unless ecotypic); however, roughly the same pattern difference was observed the following year (unpublished data). The question of the significance of multiple consecutive-day hatching of eggs in this species also remains to be answered.

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# NEW WORLD SPECIES OF *HOLCOPELTE* AND *IONYMPHA* (HYMENOPTERA: EULOPHIDAE), WITH DESCRIPTIONS OF TWO NEW SPECIES

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*Abstract.*—The genera *Holcopelte* Förster and *Ionympha* Graham (Hymenoptera: Eulophidae) are for the first time recorded from the Americas. The American *Holcopelte* comprises two new species: ***H. americana*** from Canada and the United States, and ***H. huggerti*** from the United States, Ecuador and Peru. Females and males are described for both species. *Ionympha* is represented by two species in the Americas: *I. carne* (Walker) from Canada, Ecuador and Peru, and *I. ochus* (Walker) from Canada. The hosts are unknown for all four species.

*Key Words:* Eulophidae, *Holcopelte, Ionympha,* New World, taxonomy

Förster (1856) described *Holcopelte* to include *Elachistus obscurus* (Förster, 1841). Later, he described *H. fulvipes* (1861), which was later synonymized with *H. obscura* by Bouček & Askew (1968). Thomson (1878) included *Holcopelte* as a species-group in the genus *Derostenus*; he also described *D. sulciscuta* which was later transferred to *Holcopelte* (Graham, 1959). Ashmead (1894) described six species of *Holcopelte* from the Island of St. Vincent. Later (1904), he synonymized *Holcopelte* with *Horismenus* Walker. Erdös (1958) described *Horismenus lenticeps* from Hungary, which was later transferred to *Holcopelte* (Bouček & Askew, 1968). Graham (1959) resurrected *Holcopelte* and presented a key to the two British species. Bouček (1969) described *Holcopelte stelteri* from Germany and gave a key to the four European species.

The six species described from St. Vincent by Ashmead were *Horismenus,* and prior to this paper no records of *Holcopelte* from the Americas have been published. Since only the females are known in the European species, this is the first time male *Holcopelte* are described. Hosts are only known for two of the European species (*obscura, stelteri*), both have been reared from gallmidges (Diptera, Cecidomyiidae) (Bouček & Askew 1968, Bouček 1969).

*Ionympha* was described by Graham (1959) to include *Entedon carne* and *E. ochus*; both species were originally described by Walker (1839). No additional species have been described. The genus was only known from Europe. Hosts are unknown for both species.

Abbreviations used in the text are: HE = height of an eye; MO = width of mouth opening; MS = malar space; OOL = distance between one posterior ocellus and eye; POL = distance between posterior ocelli; POO = distance between posterior ocelli and occipital margin; WH = width of head (dorsal view); WT = width of thorax across shoulders. Abbreviations of museums and private collections are as follows: BMNH = British Museum (Natural History), London, England; CH = collection of the author;

CNC = Canadian National Collections, Ottawa, Canada; LUZM = Lund University Zoological Museum, Lund, Sweden; USNM = National Museum of Natural History, Washington, D.C., USA.

### Genus *Holcopelte* Förster

*Holcopelte* Förster, 1856: 78. Type-species: *Elachistus obscurus* Förster, 1841: 40, by original designation.

Diagnosis.—Head lenticular; face, frons and occiput smooth and polished; interantennal elevation high and clearly delimited (Figs. 3, 5, 7, 9); mandibles four-dentate (Fig. 7); antenna with two small, discoid anelli; notaular depressions distinct, long and narrow (Fig. 1); thorax with a median furrow extending from posterior mesoscutum to anterior scutellum (Fig. 1); postmarginal vein shorter than stigmal vein; male four basal flagellar segments with a single whorl of long hairs at the base of each segment, fifth segment with a basal whorl and with scattered hairs in front of whorl (Figs. 4, 8).

Remarks.—The monophyly of *Holcopelte* is shown through the following synapomorphies: 1) face, frons and occiput smooth and polished; 2) notaular depressions distinct, long and narrow, and clearly delimited from remaining mesoscutum; 3) thorax with a median furrow extending from posterior mesoscutum to anterior scutellum.

The American species differ from European species by having a pale petiole and female forecoxa brown (European species with petiole dark and all coxae with same color in female).

### KEY TO THE NEW WORLD SPECIES OF *HOLCOPELTE*

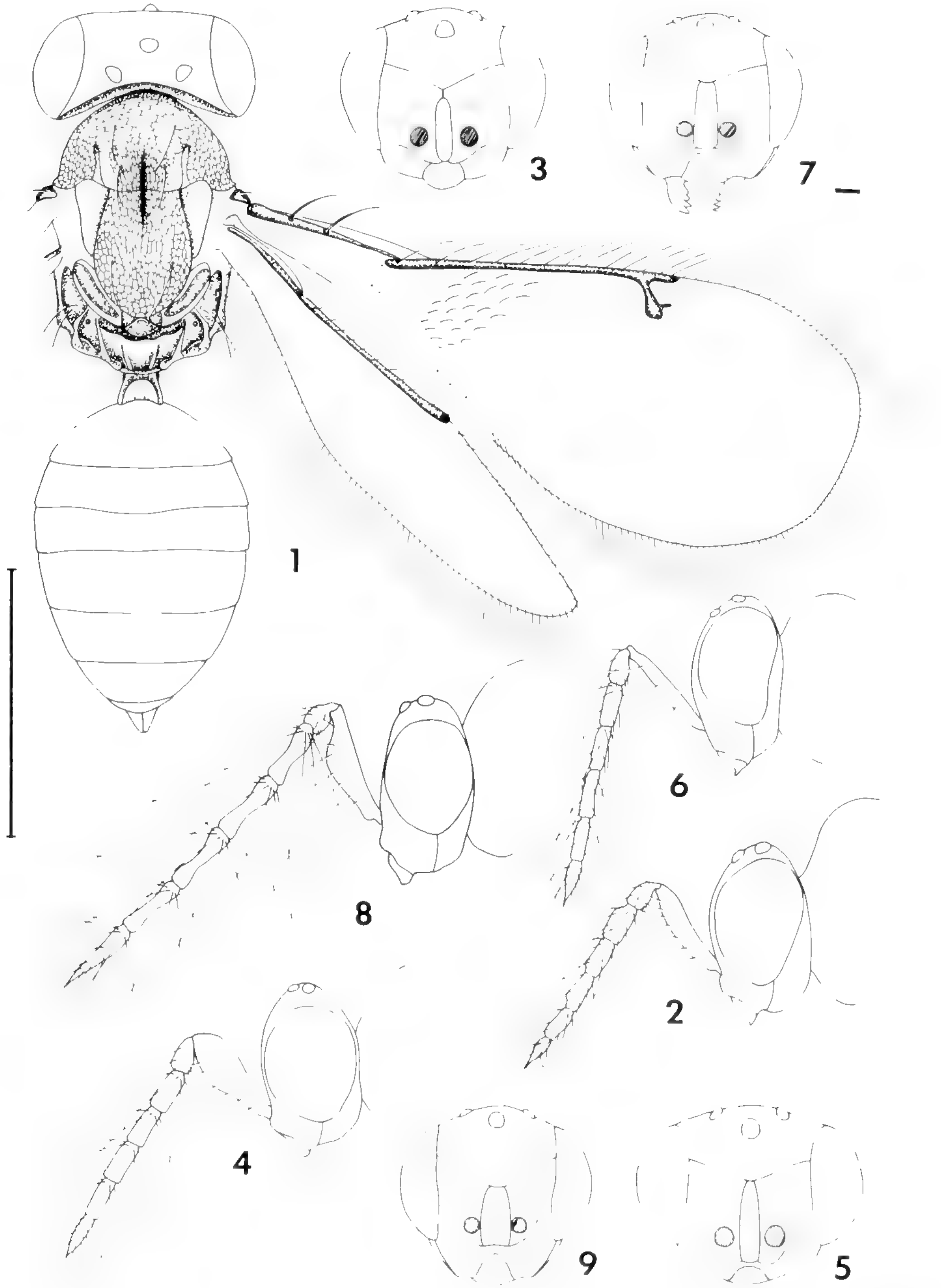
1. Females .................................. 2
– Males .................................. 3
2. Antennal scrobes joining before reaching vertical line of frontal fork (Fig. 3); scape 5.0× as long as wide with 6–7 setae along ventral edge (Fig. 2); reticulation on median thoracic dorsum engraved (slightly raised on the sides and along hind part of scutellum); cubital hair-line of forewing almost straight (Fig. 1); propodeum sculptured and with 4 plicae (Fig. 1); petiole conical without a dorsal shield ................................. *H. americana* new species
– Antennal scrobes never meet (Fig. 7); scape 8.0× as long as wide with 3–5 setae along ventral edge (Fig. 6); thoracic dorsum with raised reticulation; cubital hair-line of forewing strongly sinuate below speculum (Fig. 12); propodeum smooth to almost smooth with 2 plicae (Fig. 11); petiole quadrangular (shape transverse to slightly elongate) with a dorsal shield that covers petiolar foramen (Figs. 10, 11) .................. *H. huggerti* new species
3. Petiole small and conical, without a dorsal shield (like Fig. 1); cubital hair-line of forewing almost straight (like Fig. 1); scape apically expanded (Fig. 4); flagellum infuscate, segments 2.0–2.5× as long as wide ................................. *H. americana* new species
– Petiole distinctly elongate (1.5–3.0× as long as wide) with a dorsal shield (like Figs. 10, 11); cubital hair-line of forewing strongly sinuate below speculum (like Fig. 12); scape distinctly narrowing at apex (Fig. 8); flagellum pale, segments 3.5× (apical segment 5.0×) as long as wide and slightly narrowed medially .................. *H. huggerti* new species

### *Holcopelte americana*, NEW SPECIES

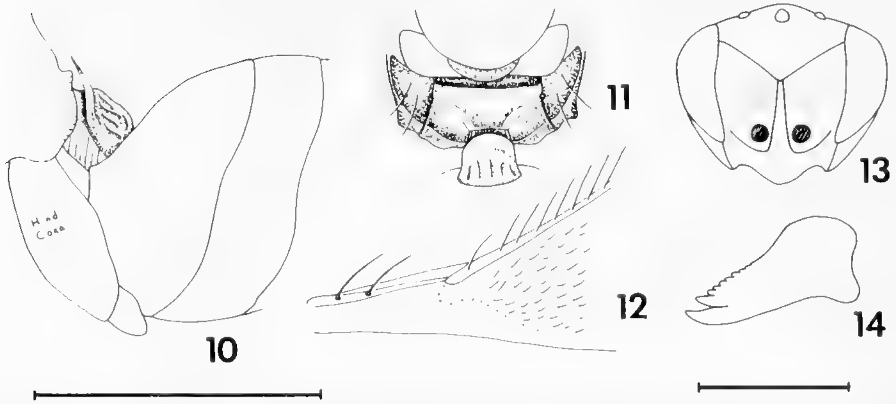
Figs. 1–5

Diagnosis.—Petiole small and conical, without a dorsal shield; cubital hair-line of forewing almost straight; reticulation on median thoracic dorsum engraved; propodeum with four plicae; ratio width/length of dorsellum = 2.4/1.0. Female: antennal scrobes joining before reaching vertical line of frontal fork; scape 5.0× as long as wide with 6–7 setae along ventral edge. Male: scape apically expanded; flagellum infuscate; flagellar segments 2.0–2.5× as long as wide; head transverse in frontal view.

Description.—*Female:* Scape yellowish-white, more or less infuscate in apical part, remaining antenna brown. Face, frons and occiput golden-green, occasionally bluish. Thorax varying from blackish to brownish, usually also with a slight golden-green tinge



Figs. 1–9. *Holcopelte* spp. 1, ♀ *H. americana* new species, habitus. 2, Same, lateral view of head. 3, Same, frontal view of head. 4, ♂ *H. americana*, lateral view of head. 5, Same, frontal view of head. 6, ♀ *H. huggerti* new species, lateral view of head. 7, Same, frontal view of head. 8, ♂ *H. huggerti*, lateral view of head. 9, Same, frontal view of head. Scale representing 0.50 mm.



Figs. 10–14. 10–12, ♀ *Holcopelte huggerti* new species. 10, Side view of petiole. 11, Dorsal view of propodeum and petiole. 12, Base of forewing. 13–14, ♀ *Ionympha carne* (Walker). 13, Frontal view of head. 14, Left mandible. Scale to the left representing 0.25 mm (Fig. 10), and 0.50 mm (Figs. 11–13); scale to the right representing 0.10 mm (Fig. 14).

(lacking in some specimens). Forecoxa brown, mid- and hindcoxae pale (usually whitish, but occasionally yellowish), remaining parts of legs varying from yellowish to predominantly infuscate. Wings hyaline or weakly infuscate, veins pale. Petiole yellowish-white. Gaster with same color as thorax. Length of body: 0.9–1.3 mm. Flagellum with all five segments free, segment I 1.5–2×, II about 2×, III and IV 2.3–2.5×, and V about 3× as long as wide. Ratios HE/MS/MO = 4.2/1.0/3.0. Malar space 1.5× as wide as width of scape in widest part. Frontal fork V-shaped. Inner orbit of eye with one row of setae. Ratios POL/OOL/POO = 8.4/3.6/1.0. Entire occipital margin with a fine and sharp edge, extending from eye to eye. Ratio WH/WT = 1.3/1.0. Pronotal collar without transverse carina. Anterior part of mesoscutum with reticulation slightly raised above the surface, with transverse meshes. Median and posterior mesoscutum with finer and engraved reticulation, meshes isodiametric or slightly elongate. Notaular depressions clearly delimited from remaining mesoscutum, narrow and extending along posterior half of mesoscutum. Midlobe of mesoscutum with a fine furrow, usually extending along posterior-median half of mesoscutum, but occasionally shorter. Scutellum with fine and engraved reticulation, slightly raised along sides and hind part. Meshes slightly to very elognate in median part, isodiametric along sides and hind part. Furrow on median mesoscutum continuing on scutellum, extension varying from anterior to entire scutellum. Dorsellum 2.4× as wide as long, with irregular sculpture and usually divided into three concave areas. Forewing rounded, hindwing with apex varying from rounded to sharply pointed. The shape of apex of hindwing is linked to the size of the specimen: small specimens have a pointed apex,while large specimens have a rounded apex. Speculum developed and closed below, cubital hair-line almost straight. Ratios length of marginal/postmarginal/stigmal veins = 7.1/1.0/1.2. Anterior part of propodeum with a relatively wide transverse furrow, extending between stigmata. With two pair of plicae, outer pair separating propodeal callus from propodeum, inner pair situated half way between outer plica and median propodeum (these are occasionally bifurcate in posterior part), with or without a median carina. With a pair of carinae ascending from upper corners of petiolar foramen, reaching half way up on propodeum. Propodeal surface usually with weak reticulation and/or other weak sculpture. Propodeal callus with two setae. Petiolar foramen triangular to rounded in shape. Petiole conical, at most as long as wide, usually slightly transverse. Gaster ovate and moderately acuminate posteriorly, about 1.2× as long as thorax + propodeum.

*Male:* Color like female, except all coxae brown and head with brighter color. Length of body: 1 mm. Scape apically expanded, flagellar segments I–III about 2×, IV and V about 2.5× as long as wide. Malar space as wide as width of scape in widest part. Ratios HE/MS/MO = 3.4/1.0/2.6, POL/OOL/POO = 14.0/6.0/1.0, WH/WT = 1.5/1.0. Gaster slightly longer than thorax + propodeum. Otherwise as in female.

Type material.—Holotype ♀ labelled: "USA: West Virginia, Greenbrier Co., 10 miles E. Richwood, Summit Lake, 29.vii.1983, leg. L. Huggert," in LUZM. Paratypes: 2 ♀ with same label as holotype; 1 ♀ "USA: West Virginia, Greenbrier Co., Richwood, Summit Lake, 27.vii.1983, leg. L. Huggert"; 2 ♀, 1 ♂ "USA: West Virginia, Pocahontas Co., Falls of Hills Creek, 22.vii.1983, leg. L. Huggert"; 3 ♀ "USA: West Virginia, Pocahontas Co., Falls of Hills Creek, Monongahela Forest, 26.vii.1983, leg. L. Huggert"; 1 ♂ "USA: West Virginia, Pocahontas Co., Dogway Road, Monongahela Forest, 26.vii.1983, leg. L. Huggert"; 1 ♀ "Canada: Quebec, Bouchette, Lac Roddick, 12.ix.1982, leg. L. Huggert." These paratypes deposited: 3 ♀, 1 ♂ in CH, 5 ♀, 1 ♂ in LUZM, 1 ♀ in USNM; 1 ♀ "N.S.C.B.H.N.P., Skyline Trail, 25.vii. 1983," "Birch PG 635802, B.R.I. Survey"; 1 ♀ "Prince Edward I., Sand Banks Prov. Pks., 25.vii.1982, L. Masner"; 1 ♀ "St. Lawrence Is. Nat. Park, Ontario, Thwartway Is.," "19.vii.1976, L. Masner, Code 4212-7"; final three paratypes in CNC.

Distribution.—Canada (Nova Scotia, Ontario, Prince Edward Island, Quebec) and the United States (West Virginia).

## ***Holcopelte huggerti,* New Species**

Figs. 6–12

Diagnosis.—Petiole quadrate (♀), or 1.5–3.0× as long as wide (♂) with a thin dorsal shield that covers petiolar foramen; cubital hair-line strongly sinuate below speculum; reticulation on thoracic dorsum raised; midlobe of mesoscutum separated from scutellum by a narrow transverse furrow; propodeum with two plicae; ratio width/length of dorsellum = 5.9/1.0. Female: antennal scrobes never meet; scape 8.0× as long as wide, with 3–5 setae along ventral edge. Male: scape narrowed apically; flagellum pale; flagellar segments 3.5× (apical segment 5.0×) as long as wide and slightly narrowed in median part; head about as high as wide in frontal view.

Description.—*Female:* Scape yellowish-white, remaining antenna infuscate. Frons and occiput dark brown with a weak golden or golden-green tinge. Thorax dark brown with a golden tinge. Forecoxa brown, mid- and hindcoxae pale (usually white, but occasionally yellowish), remaining parts of fore- and midlegs usually more or less infuscate (especially femora), hindleg usually predominantly pale. Wings hyaline with pale veins. Petiole yellowish-white. Gaster with same color as thorax. Length of body: 0.9–1.3 mm. Scape narrow with 3–5 setae along ventral edge. All five flagellar segments free, segment I about 2.8×, II, III and V about 3.8×, and IV about 3.4× as long as wide. Ratios HE/MS/MO = 4.2/1.0/2.4. Malar space about 2.5× as wide as width of scape in widest part. Frontal fork V-shaped. Inner orbit of eye with one row of setae. Ratios POL/OOL/POO = 13.0/10.0/1.0. Entire occipital margin with a fine and sharp edge, extending from eye to eye. Ratio WH/WT = 1.5/1.0. Pronotal collar without transverse carina. Mesoscutum and scutellum with fine but distinctly raised reticulation, stronger along sides and hind part of scutellum. Meshes elongate in median part of both mesoscutum and scutellum, otherwise isodiametric. Median furrow on thorax weak, extending from posterior ⅓ of mesoscutum to anterior ⅓ of scutellum, sometimes absent on mesoscutum. Notaular depressions like *americana.* Midlobe of mesoscutum separated from scutellum by a narrow furrow. Dorsellum short, 5.9× as wide as long, with surface convex. Shape of wings like *americana*. Speculum present and closed below, cubital hair-line strongly sinuate below speculum. Ratios length of marginal/postmarginal/stigmal veins = 7.4/1.0/1.3. Anterior part of propodeum with a relatively wide transverse furrow, extending between stigmata. Only one pair of plicae present, situated in level with stigmata. Also with a pair of carinae ascending from upper corners of petiolar foramen, reaching about half way up on propodeum. Propodeal surface otherwise smooth. Propodeal callus with two setae. Petiolar foramen quadrate, upper margin rounded. Petiole quadrate, with a thin dorsal shield anteriorly, shield covering petiolar foramen. Gaster ovate, more acuminate than *americana* posteriorly, about 1.3× as long as thorax + propodeum.

*Male:* Color like female, except entire antenna pale and all coxae infuscate. Length of body: 1.1–1.4 mm. Scape narrowed apically. Flagellar segments I–IV about 3.5×, and V about 5.0× as long as wide. Malar space 1.2× as wide as width of scape in widest part. Ratios HE/MS/MO = 2.9/1.0/2.0, POL/OOL/POO = 15.0/7.2/1.0, WH/WT = 1.3/1.0. Median furrow on thorax extending along entire scutellum in some specimens. Petiole 1.5–3.0× as long as wide. Gaster slightly longer than thorax + propodeum. Otherwise as in female.

Type material.—Holotype ♀ labelled: "USA: West Virginia, Greenbrier Co., 10 miles E. Richwood, Summit Lake, 29.vii.1983, leg. L. Huggert" in LUZM. Paratypes: 2 ♀ with same label as holotype; 1 ♀ "USA: West Virginia, Pocahontas Co., Falls of Hills Creek, Monongahela Forest, 26.vii.1983, leg. L. Huggert"; 1 ♀ "Peru: Huanucu, Tocache, 2.ii.1984, leg. L. Huggert"; 1 ♀ "Peru: Cusco, Machu Pichu, 21.xii.1983, leg. L. Huggert"; 2 ♀ 6 ♂ "Peru: Cusco, Aqua Caliente, 28.xii.1983, leg. L. Huggert"; 1 ♀ "Ecuador: Napo, Lumbaqui, 10–11.iii.1983, leg. L. Huggert"; 1 ♀ "Ecuador: Pichin, Rio Palenque, 4.ii.1983, leg. L. Huggert"; 2 ♀ "Ecuador: Pichin, Puerto Quito, 2.iii.1983, leg. L. Huggert"; 4 ♀ 2 ♂ in CH, 6 ♀ 3 ♂ in LUZM, 1 ♀ 1 ♂ in USNM.

Distribution.—The United States (West Virginia), Ecuador and Peru.

### Genus *Ionympha* Graham

*Ionympha* Graham, 1959: 199. Type-species: *Entedon ochus* Walker, 1839: 21, by original designation.

Diagnosis.—Mandibles multidentate, long and narrow (Fig. 14); antennal scrobes never meet (Fig. 13); frons below fork with fine reticulation at least in some places; antenna with two small and discoid anelli; male flagellar segments with hairs placed evenly (not only a basal whorl as in *Holcopelte*); notaular depressions shallow and not delimited from remaining mesoscutum; propodeum smooth and shiny without plicae; male gaster with a pale subbasal spot.

Remarks.–The monophyly of *Ionympha* is shown through the following synapomorphies: 1) mandibles long and narrow; 2) male gaster with a pale subbasal spot.

For identification and description of the species see Graham (1959: 199–200). The key in Graham can be supplemented with the following character: female *I. carne* with 2–5 setae on propodeal callus, 7–9 setae in *ochus*.

### *Ionympha carne* (Walker)

Figs. 13–14

*Entedon carne* Walker, 1839: 123.

*Ionympha carne* (Walker), Graham, 1959: 200.

Material.—CANADA: 1 ♀ Ontario, Rondeau Prov. Park, 26.viii.1982. ECUADOR: 1 ♀ Pichin, Tinalandia, 800 m, 7.ii.1983. PERU: 1 ♀ Cusco, Ollantaytambo, 19.xii.1983; 1 ♀ Cusco, Machu Pichu, 21.xii.1983. All leg. L. Huggert (1 ♀ in CH, 3 ♀ in LUZM). Type material of *E. carne* in BMNH (not seen).

Remarks.—Most European specimens of this species have dark coxae and remaining parts of legs predominantly infuscate. Three of the females from the Americas have mid- and hindcoxae and remaining hindleg pale. However, there are some European specimens with hindcoxa pale, and one of the females from Peru has all legs entirely infuscate. The infuscation of the legs frequently shows a high degree of intraspecific variation in many species of Eulophidae and I do not regard this difference in color between European and American specimens as a species character. American specimens of *I. carne* have, on the average, a weaker reticulation on the thoracic dorsum than European specimens. The midlobe of mesoscutum is usually partly, and the scutellum is predominantly, smooth and polished in American specimens. However, in some species of Eulophidae with a Holarctic distribution, e.g. *Chrysocharis prodice* (Walker), American specimens tend to have a weaker reticulation on the thoracic dorsum (Hansson 1987). This tendency becomes even more apparent in specimens from the southern Nearctic region.

Distribution.—West Palearctic (Bouček & Askew 1968), Canada (Ontario), Ecuador and Peru. *Ionympha carne* was previously not recorded from the Americas.

### *Ionympha ochus* (Walker)

*Entedon ochus* Walker, 1839: 21.
*Ionympha ochus* (Walker), Graham, 1959: 200.

Material.—CANADA: 1 ♀ British Columbia, N. Vancouver, 31.viii.1960, S. M. Clark (CNC). This specimen agrees well with European specimens. Type material of *I. ochus* in BMNH (not seen).

Distribution.—West Palearctic (Bouček & Askew 1968) and Canada (British Columbia). *Ionympha ochus* was previously not recorded from the Nearctic Region.

## ACKNOWLEDGMENTS

I am particularly grateful to Lars Huggert (Lund, Sweden) who collected the majority of the material forming the base of this paper. My thanks also to R. Danielsson (LUZM), M. E. Schauff (USNM) and C. M. Yoshimoto (CNC) for loan of material.

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# NATURALLY OCCURRING HOST SITES FOR XYLOPHILIC CECIDOMYIIDAE (DIPTERA)

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*Abstract.*—Existing data on host sites for xylophilic Cecidomyiidae larval development are derived from observations of sawn trees and logs. Field studies of hardwood trees at three sites in northeast Ohio show that strong winds and animal activity break live branches of suitable size and thus expose vessels of $\geq 75\ \mu$ which are used for larval development. Such damaged branches can support large populations of midges. Larvae develop in both the proximal and distal sides of the break. Branches remain suitable for oviposition and larval development for one to several months, depending on branch diameter and weather conditions.

*Key Words:* wood loving, tree damage, squirrel activity

Xylophilic Cecidomyiidae use freshly exposed vessels of hardwoods as a larval habitat. Relationship between host selection and vessel diameter has been previously reported (Rock and Jackson 1985, 1986). As with that of other investigators (Kieffer 1900, Brues 1922), our initial encounter with these cecidomyiids began when we observed females swarming on the cut surfaces of logs and stumps of trees exposed in logging operations. Although we also used cut logs during earlier studies, we speculated on the availability of such niches under natural conditions. Our current investigation examines 1) the role of strong winds and animal activity in exposing larval niches, 2) utilization of vessels in live branches that remain on the tree, 3) the number of larvae that one branch can support and 4) the length of time after exposure that a branch remains suitable for use.

## METHODS

Storm and squirrel damage.—Two sites in northeast Ohio were monitored for two years (1985 and 1986) for live, broken branches. One site was a small island of approximately 7500 square meters located near a lake shore with five mature oak (*Quercus alba* L.) and one mature ash (*Fraxinus americana*) trees (known xylophilic cecidomyiid hosts (Rock and Jackson 1986)). The other was part of a large suburban garden with a study area of 5625 square meters with five mature oak and three mature ash trees. The areas below the trees were mowed regularly to facilitate collection of fallen twigs and branches. We recorded the diameter of only the live branches because previous studies have shown that dead wood is not a suitable larval habitat. Some larger branches were kept at the field site to monitor their use by cecidomyiids. The suitability of the branches for larval development was verified by subsequent collection of larvae from the branch ends.

Squirrels were active at the field sites and numerous live host tree branches were collected that squirrels had severed by chewing. Branches broken by squirrels were

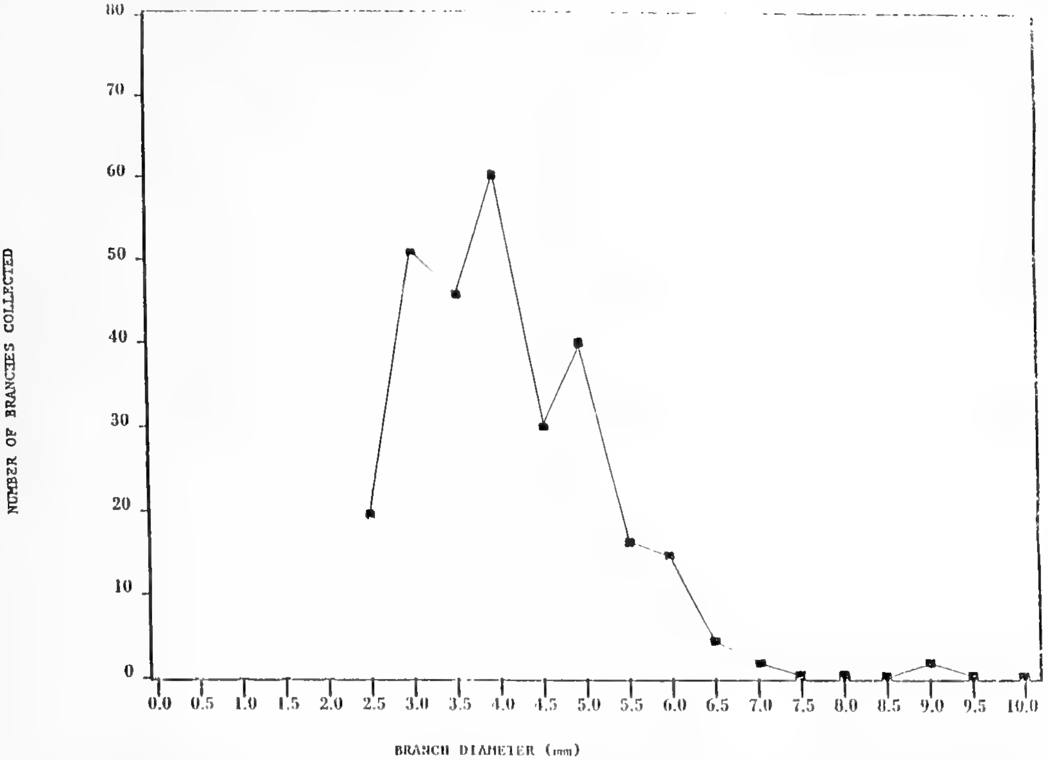

Fig. 1. Number and size of live branches broken from hardwood hosts at test sites. Branches <2 mm d not included in collection.

readily identified by teeth marks. Branch diameters were recorded.

Suitability of proximal section of broken branches.—In earlier studies, we had for convenience used only the severed branch sections. The current study investigates the use of the intact basal parts as their use would double the number of potential larval development sites.

We cut a total of fifty-nine branches ranging from 13 mm d to 30 mm d from ash, oak and elm trees at field sites in Akron and Orrville, Ohio. The severed branches were placed at the base of the tree to confirm the presence of females. Branch ends on the trees were left exposed for ten days to allow females to oviposit. After this time, the ends were covered by a plastic cup; the branch and cup were then covered with a nylon bag to hold the cup in place. Rain wetting the branches stimulated the emergence of larvae. We recorded the number of larvae that fell into the cups without identifying them to species. The branches were uncovered for three days to allow for possible further oviposition; the cups were then replaced. This procedure was repeated for up to seven weeks.

Potential larval yield from small branches.—We had previously determined that host branches of 6 mm or greater in diameter usually contain xylem vessels of $\geq 75$ $\mu$ d, which are suitable for larval development (Rock and Jackson 1986), but never recorded the number of midges that emerged from indvidual twigs. Twenty sassafras (*Sassafras albidum* (Nutt.) Nees) branches with diameters varying from 3 mm to 20 mm were offered to a population of 300 caged *Xylodiplosis longistylus* Gagné females for one week. The branches were held at room temperature in plastic bags for 14

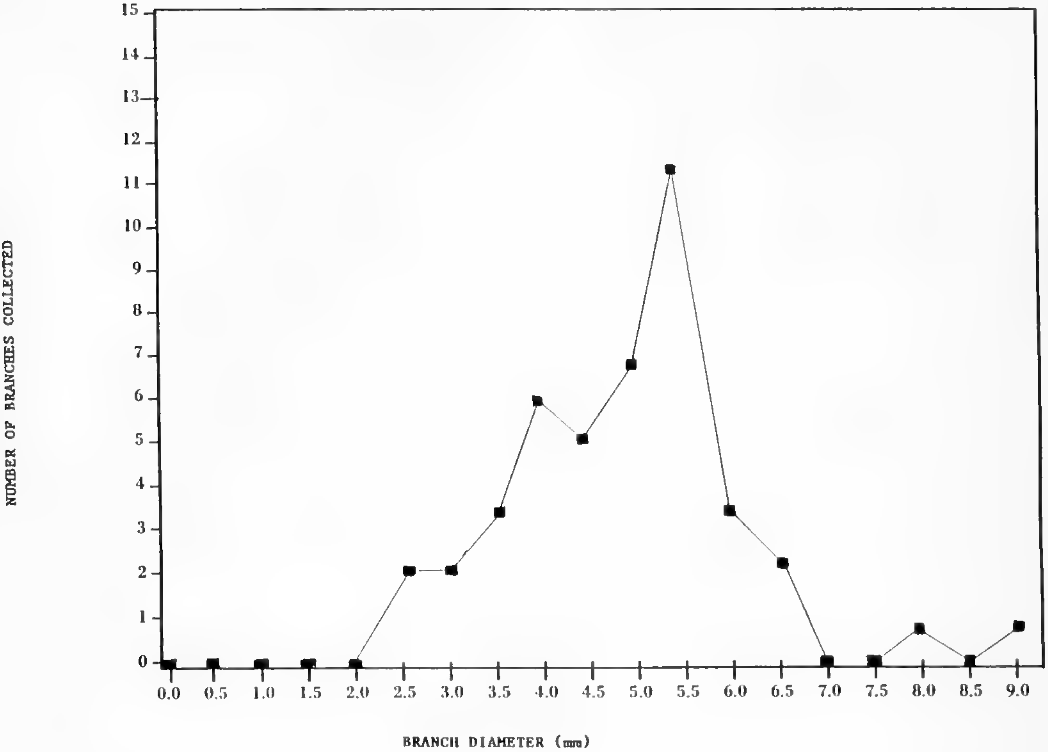

Fig. 2. Number and size of live branches broken from host trees by squirrel activity.

days. Each was then soaked in a separate container of water, and the number of larvae emerging from both exposed ends was recorded.

Period of suitability of cut branches for larval development.—To establish if there was a connection between length of use of a severed branch and branch diameter, we monitored larval emergence in branch samples of various diameters from the field sites. Unidentified xylophilic larvae emerged from vessels in approximately 14 days after oviposition if the branch was soaked in water (Rock and Jackson 1985). When a wood sample ceased to yield larvae, we assumed it had lost its attractiveness to females approximately two weeks earlier. We then compared duration of attractiveness to sample diameter.

## Results and Discussion

Strong winds create a source of suitable oviposition sites. Although the majority of the live branches broken from host trees during an entire summer are <5 mm d (Fig. 1), high winds break off some branches of 6 mm d or greater, which contain suitably sized vessels. Branches with diameters ranging from 15 mm to 35 mm were occasionally broken throughout the summer. At other locations we observed major damage due to lightning and heavy snow that also created sources of exposed vessels. As discussed below, the availability of larger branches is very important as they can support several generations of gall midges each summer.

Squirrels expose the ends of live branches when they feed and build their nests (Shorten 1954). Although most of the branches are less than 6 mm d (Fig. 2), some larger branches are severed and can serve as suitable sites for midge development. Gray squirrels (*Sciurus nigra*) are known to build nests in many of the hardwoods that are also hosts to xylophilic midges. Uhlig (1955), in

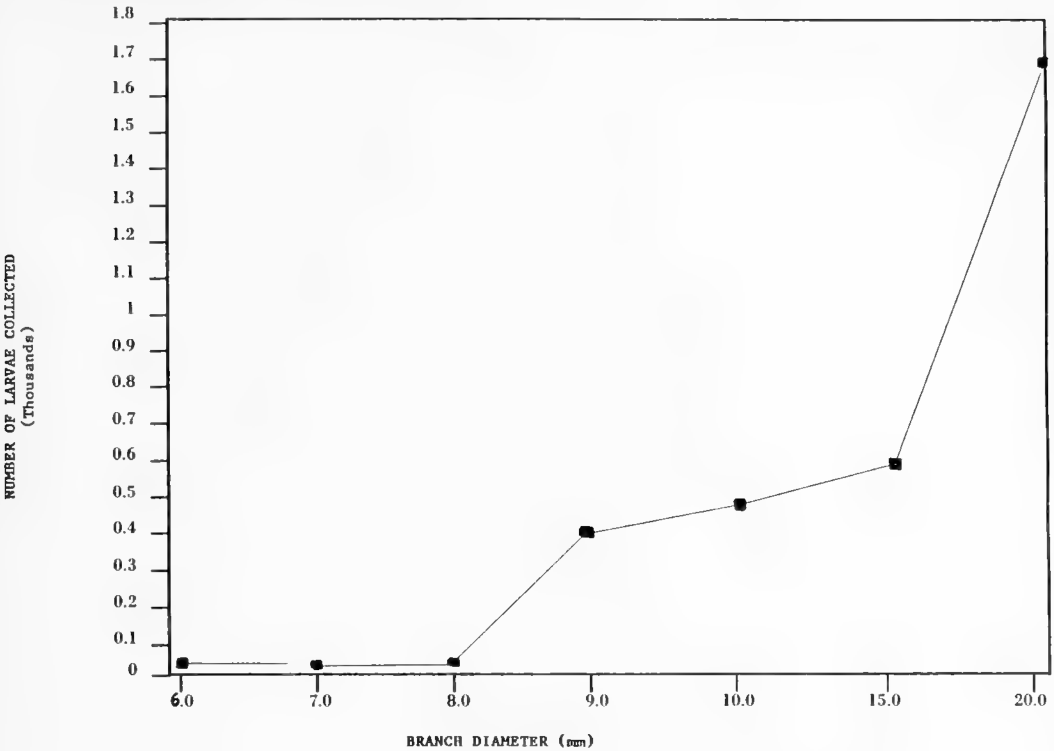

Fig. 3. Relationship of number of larvae collected to branch diameter: *Sassafras albidum.*

an extensive study of the gray squirrel in West Virginia, noted the use of oak, elm, and hickory, and less frequently willow, walnut, and sassafras, in nest building. Walnut and oak trees at our field sites contained squirrel nests. Leaf nests built of twigs and leaves from the tree in which they are located have been noted from early spring throughout the summer months. Juvenile squirrels are the primary leaf nest builders, and the actual number of nests is directly proportional to the rearing success of the spring and summer litters (Uhlig 1955). One juvenile may build more than one nest throughout the summer and early fall. Thus, with several juvenile squirrels in an area, a supply of exposed branches exists for several months.

Fig. 3 summarizes a laboratory study, using sassafras, which shows a direct correlation between branch diameter and the number of larvae collected. We previously determined that larvae require vessels of $\geq 75\ \mu$ d for development and that it is possible to predict the number of potential larval habitats based on the number of vessels/mm$^2$ in the sapwood. The 6 to 8 mm d branches are suitable for larval development but each yielded only a few larvae. However, the 20 mm d sassafras sample had approximately 1850 vessels $\geq 75\ \mu$ d/mm$^2$ in each end, and it yielded over 1700 larvae.

Preliminary field data indicate that actual utilization of vessels is much less than in laboratory samples. A 12 mm d ash branch, for example, yielded 6 larvae, and a 50 mm d branch yielded 100 larvae during 12 days of field collecting. In natural conditions, small, broken branches are available to the flies throughout the summer and can support small overlapping populations. Although large branches are available less frequently, they permit rapid population increases and provide larval niches for extended periods of time.

The live basal sections of severed branch-

Table 1. Relationship of host sample diameter to length of attractiveness.

| Host Plant | Diameter (cm)* | Length of Attractiveness (Weeks) |
|---|---|---|
| *Juglans nigra* L. | 35 | 15 |
| *Fraxinus americana* | 22 | 10 |
| *Carya ovata* (Mill.) K. Koch | 21 | 12 |
| *Quercus alba* L. | 14 | 14 |
| *Ulmus americana* L. | 12 | 14 |
| *Populus deltoides* Bartr. | 12 | 10 |
| *U. americana* | 11 | 11 |
| *Salix babylonica* Marsh | 9 | 8 |
| *Sassafras albidum* (Nutt.) Nees | 7 | 8 |
| *F. americana* | 5 | 8 |
| *F. americana* | 2 to 4 | 8 |
| *F. americana* | 1 to 2 | 6 |
| *F. americana* | 0.6 to 1 | 4 |

* All samples 25 to 35 cm long.

es are attractive to females and suitable for larval development. Larvae emerged from most of the attached broken branches, the largest number collected at one time being 30 from a 30 mm ash branch. No larvae emerged after the sixth week of exposure, and we assumed branches had ceased to attract female midges.

The time period during which midges utilize a cut branch (Table 1) is directly proportional to its diameter. As the life cycle of most xylophilic species is approximately 4 weeks, during the summer in northeast Ohio it is possible for one 35 cm d log to support three generations of gall midges. Major factors that limit the period of attractiveness are speed of decay and rainfall. General observations over several summers indicate that abnormally wet periods promote fungal growth on exposed branch ends and so reduce the length of time that a log is suitable. Weather records, however, indicate that summers with increased shower activity are associated with more frequent episodes of high winds which lead to an increase in the number of severed branches (Robert Thompson, personal communication, National Weather Service, North Canton, Ohio 1988).

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91(1), 1989, pp. 71–80

# TWO NEW TERRESTRIAL ISOPODA (ONISCIDEA) FROM CORALLINE CAYS OF VENEZUELA'S CARIBBEAN COAST

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*Abstract.*—Two terrestrial, halophilous isopods, ***Metastenoniscus neotropicalis*** **n. sp.** (Stenoniscidae) and ***Armadilloniscus caraibicus*** **n. sp.** (Scyphacidae) are described from coralline cays of Venezuela's Caribbean coast. *Buchnerillo litoralis* Verh. and *Stenoniscus pleonalis* Aubert and Dollfus are reported from the Caribbean region.

*Key Words:* Isopoda, Oniscidea, Neotropical, Caribbean, *Metastenoniscus neotropicalis* n. sp., *Armadilloniscus caraibicus* n. sp., *Buchnerillo litoralis, Stenoniscus pleonalis*

Knowledge of the Venezuelan terrestrial isopoda fauna is reported in a few post-worldwar papers: Brian 1957, Vandel 1952, 1968, 1972, Andersson 1960, Mulaik 1960, Strinati 1971, Schultz 1971, 1983, 1984, following the classic studies of Van Name 1936, 1940, 1942. We have followed in general the terminology proposed by Holdich 1984, Holdich et al. 1984. Our work is mostly based on SEM (Scanning Electron Microscopy).

The two new species that we describe belong to the halophilous seacoast fauna. The tergites covered by longitudinal ribs suggest that these species belong to the eco-morphological category of *creepers* (Schmalfuss 1984, Paoletti 1987).

## ONISCOIDEA

### Stenoniscidae

### *Metastenoniscus neotropicalis* n. sp.

Type locality. Coralline key (Cayo) of Playuela, Parque Morrocoy, estado Falcon, Venezuela. 28 females and 12 males were collected in soil litter of *Coccolobis uvifera* (L) Jacq. (Polygonaceae), by M. G. Paoletti on January 1, 1986 (Paoletti 1988).

Male holotype, allotype and paratypes are located in the M. G. Paoletti collection; 3 female paratypes are deposited in the Museo Zoologico of the Padova University; 3 female paratypes are located in the general-collection of Instituto Museo de Zoologia Agricola, Universitad Central de Venezuela, Maracay, Aragua, Venezuela.

Diagnosis. This new species is similar to *Metastenoniscus osellai* Taiti and Ferrara, 1981. The smaller body is more cylindrical and holds less enlarged epimera. The telson is shorter and three-lobed.

Dimensions: length males: 1.4–1.86 mm, mean 1.57 mm; width males: 0.42–0.56 mm, mean 0.50; length females: 1.48–2.42 mm, mean 2.14 mm; width females: 0.48–0.84 mm, mean 0.71 mm (Figs. 1, 2).

Body ornamentation: consists mainly of subcircular plaques (Figs. 4A, C, D); body shape subparallel, costulated, light violet colored; pereonites I–IV without medial rib (Figs. 3A, C).

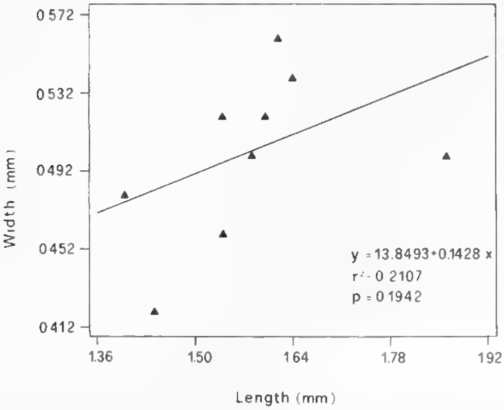

Fig. 1. Regression for male dimensions of *Metastenoniscus* neotropicalis n. sp.

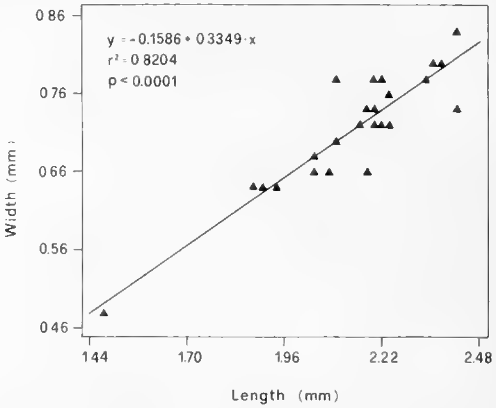

Fig. 2. Regression on female dimensions of *Metastenoniscus neotropicalis* n. sp.

Head: with three posterior main tubercles and two median main tubercles (Figs. 3A, B, C); eye with 3–4 ommatidia; antenna with flagellum consisting of two articles; the second article bears on its foreword-facing surface three aesthetascs (Figs. 3E, F). Antennule two-articulated with three apical aesthetascs, the exterior occasionally broken at the base (fig. 4E).

Telson: short and distinctly three-lobed (Figs. 3C, D; 4B, D).

Uropods: the basis is longer than wide (Fig. 4B), the exopod bears distally a spike of 4–5 aesthetascs (Figs. 4D, F); the endopod much longer than exopod (Figs. 4C, D), thickened in the middle, end with a spike of three elements (Fig. 4C).

Pleopods: male endopod of first and second pair are little differentiated (Fig. 5).

Affinities. *M. neotropicalis* n. sp. is distinct from *Metastenoniscus osellai* Taiti and Ferrara, 1981, described from Bali by the following features:

1. females and males are smaller;
2. epimeral appendages less developed and body smaller;
3. head with a different arrangement of tubercles especially in the posterior part: five on *M. osellai* and three on *M. neotropicalis* n. sp.;
4. pereonites I and II with only a hind vestige of medial rib; in *M. osellai* the pereonite from 1 to 4 has medial costa well developed (Taiti and Ferrara 1981 Figs. 1C and 2C);
5. telson shorter and distinctly three-lobed;
6. uropod exopods shorter and with wider basis.

Habitat. Found under *Coccolobis uvifera* (L.) Jacq. (Polygonaceae) (uva de plaja) litter, eating decayed litter tissue (Paoletti 1987 Figs. 7D, G, H). This isopod was not yet found in the intertidal zone but strictly in the interior part of the coralline cays and above the upper tidal level.

Distribution. Discovery of *M. neotropicalis* n. sp. considerably enlarges the known geographic range of the family Stenoniscidae. In fact *Metastenoniscus* is now represented not only in the Oriental region (Bali and the Andaman Islands) but also in a Pantropical belt including the Caribbean region. That they only now have been discovered in the Caribbean region is probably due to their small size.

Discussion. *Stenoniscus pleonalis* Aubert and Dollfus, 1890 (sensu Vandel 1962) is easily distinguishable from *Metastenoniscus osellai* (Taiti and Ferrara, 1981) and from *M. neotropicalis* n. sp. It was reported only rarely beyond the Mediterranean region and in the Neotropical region only twice (Vandel 1968, Schultz 1972). We collected *Stenoniscus pleonalis* Aubert and Dollfus (sensu

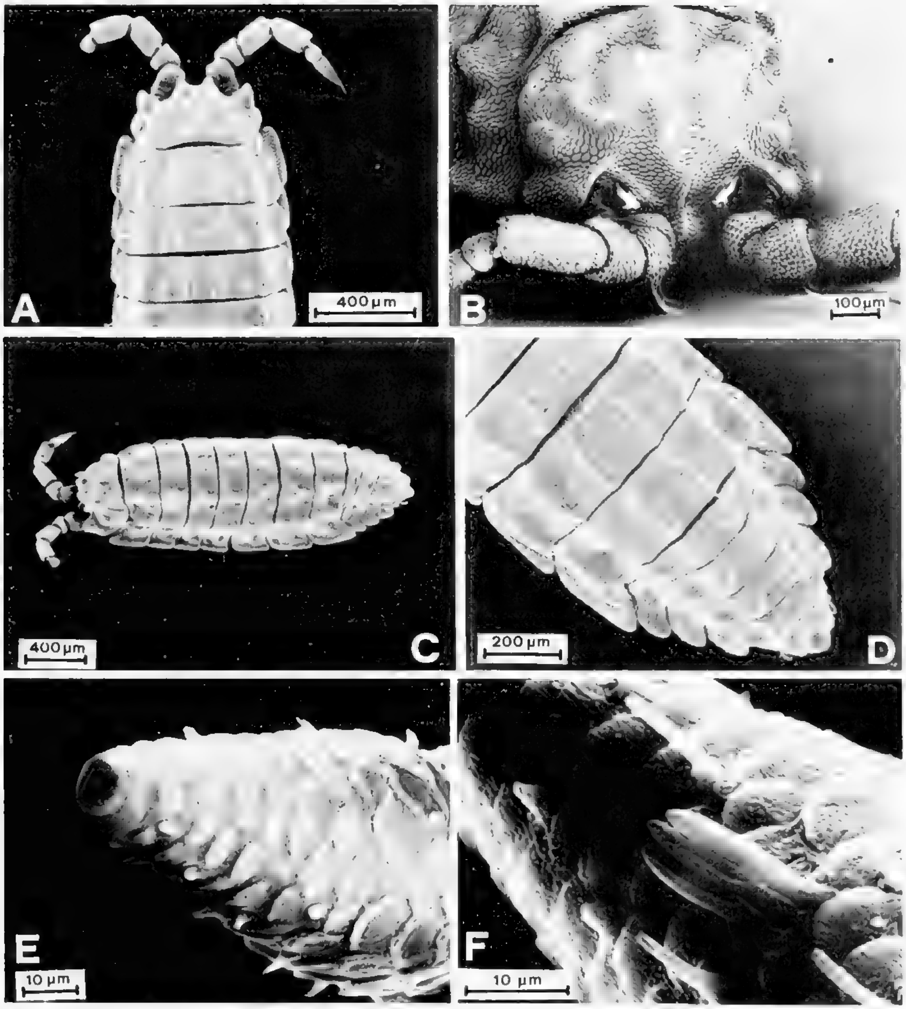

Fig. 3. *Metastenoniscus neotropicalis* n. sp. Female: A dorsal view, B head frontal view, C lateral view, D pleon and telson, E and F second antennal flagellum article from dorsal and ventral views.

Vandel 1962) in Florida Cays, Tavernier Creek, on rocky beach: in the soil, under *Posidonia* and on coconut drift in the beach, M. G. Paoletti, October 26, 1987. This latter observation is interesting. Under the *Posidonia* drift in the same location was collected one female of *Buchnerillo litoralis* Verhoeff, 1943, which represents a first record for the Neotropical region (Schultz and Johnson 1984), and *Vandeloscia culebre* (Moore, 1901), *Tylos niveus* Budde-Lund. and *Armadilloniscus ellipticus* (Harger, 1878).

## ONISCOIDEA

### Scyphacidae

### *Armadilloniscus caraibicus* n. sp.

Type locality. Coralline cays (Cayos) of Parque Morrocoy, estado Falcon, Venezuela: Cayo Sombrero, one gravid female 31.XII.1985; Cayo Cico, 8 males, 16 females, 7 gravid females, 3.I.1986 were collected by M. G. Paoletti. Isopods were collected in the intertidal zone under coralline rocks lying on the sandy beach at Cayo Cico; at Cayo Sombrero the gravid female was

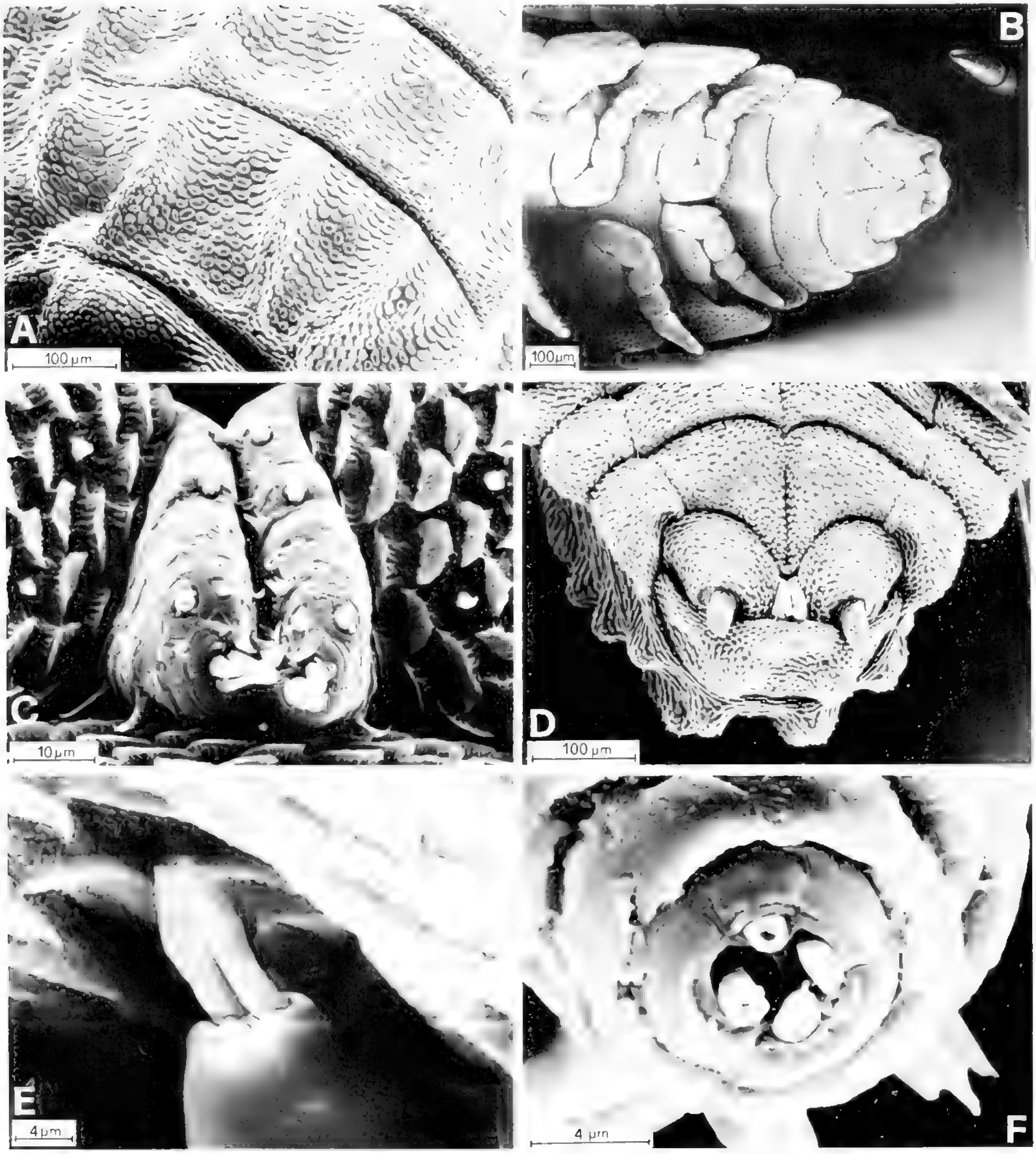

Fig. 4. *Metastenoniscus neotropicalis* n. sp. Female: A I and II pereonites, B ventral view of hind pereon, pleon and uropods, C uropodal endopods, D below view of pleon and uropods, E second article of antennulae with aesthetascs, F uropodal exopod.

found among small woody debris on the coarse sandy beach (Paoletti 1988).

Male holotype, allotype and paratypes are located in M. G. Paoletti collection; 3 female paratypes are deposited in the Museo Zoologico of the Padova University; 3 female paratypes are deposited in the general-collection of Instituto Museo de Zoologia Agricola, Universitad Central de Venezuela, Maracay, Aragua, Venezuela.

Diagnosis. Body elliptical, dull brown, covered with prominent ridges of tubercles on the head, forming ribs on the pereon and pleon (Figs. 10, 11). Ornamentation consists of circular plaques (Figs. 11F, H) and digitiform trichomes.

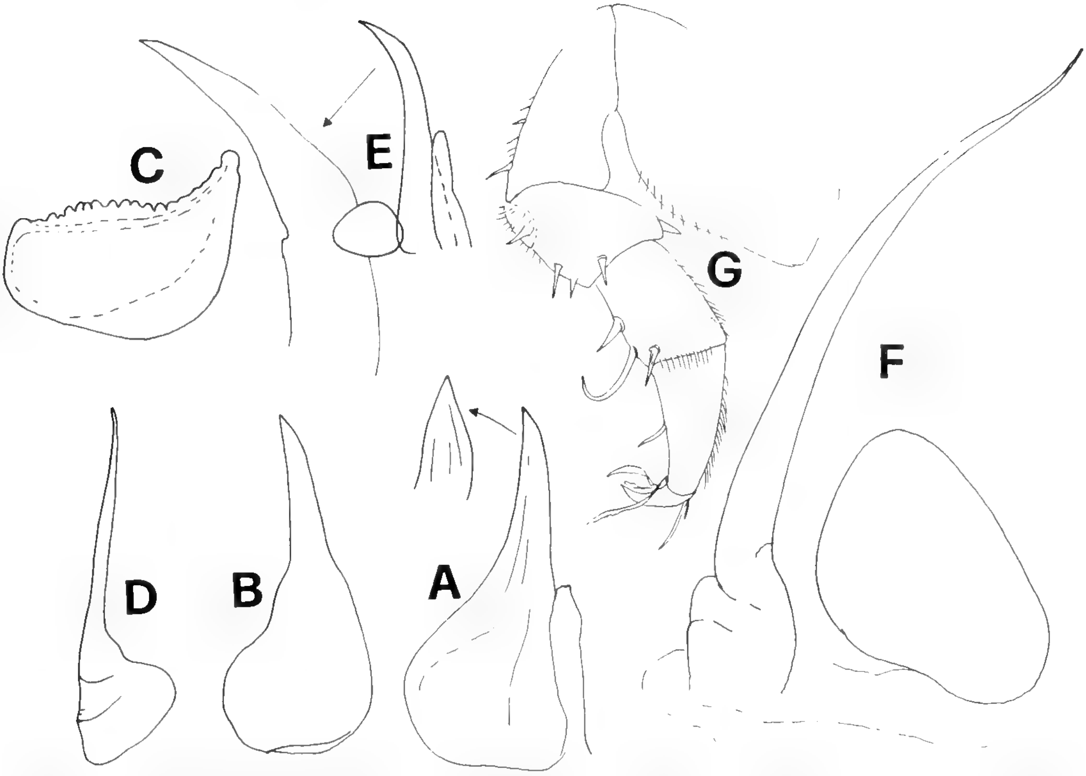

Fig. 5. *Metastenoniscus neotropicalis* n. sp. Male, A and B pleopod I endopods, C pleopods I exopod, D pleopods II endopod. *Armadilloniscus caraibicus* n. sp. Male, E pleopods I, F pleopods II, G VII male pereopods.

Dimensions: length males: 1.92–2.46 mm, mean 2.27; width males: 0.84–1.26 mm, mean 1.05 (Fig. 6); length non gravid females: 1.25–3.9 mm, mean 2.34; width non gravid females: 0.75–1.92 mm, mean 1.095 (Fig. 7); length gravid females: 2.85–3.36 mm, mean 3.0; width gravid females: 1.35–1.56 mm, mean 1.44 (Fig. 8); 6–9 pulli per gravid female were counted (Fig. 9).

Head: with lateral lobes truncated at tip and median lobe pointed, with three main tubercles in the posterior and two in the

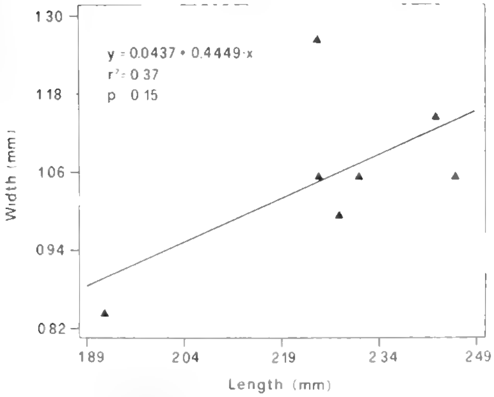

Fig. 6. *Armadilloniscus caraibicus* n. sp. Regression of male dimensions.

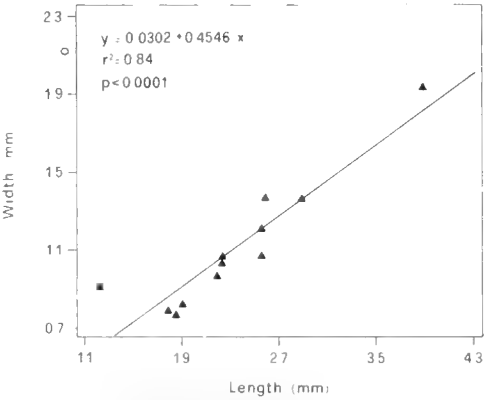

Fig. 7. *Armadilloniscus caraibicus* n. sp. Regression of non gravid female dimensions.

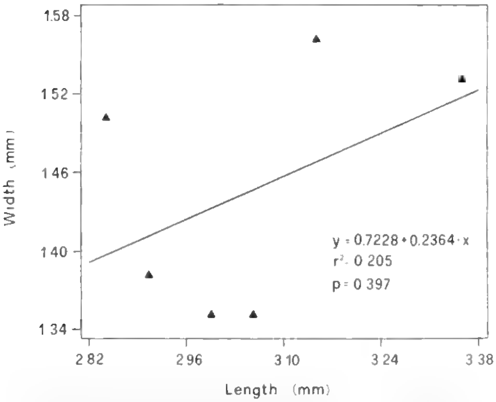

Fig. 8. *Armadilloniscus caraibicus* n. sp. Regression of gravid female dimensions.

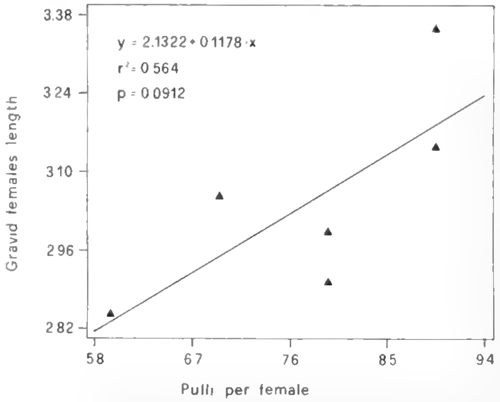

Fig. 9. *Armadilloniscus caraibicus* n. sp. Regression of gravid female length and pulli per female.

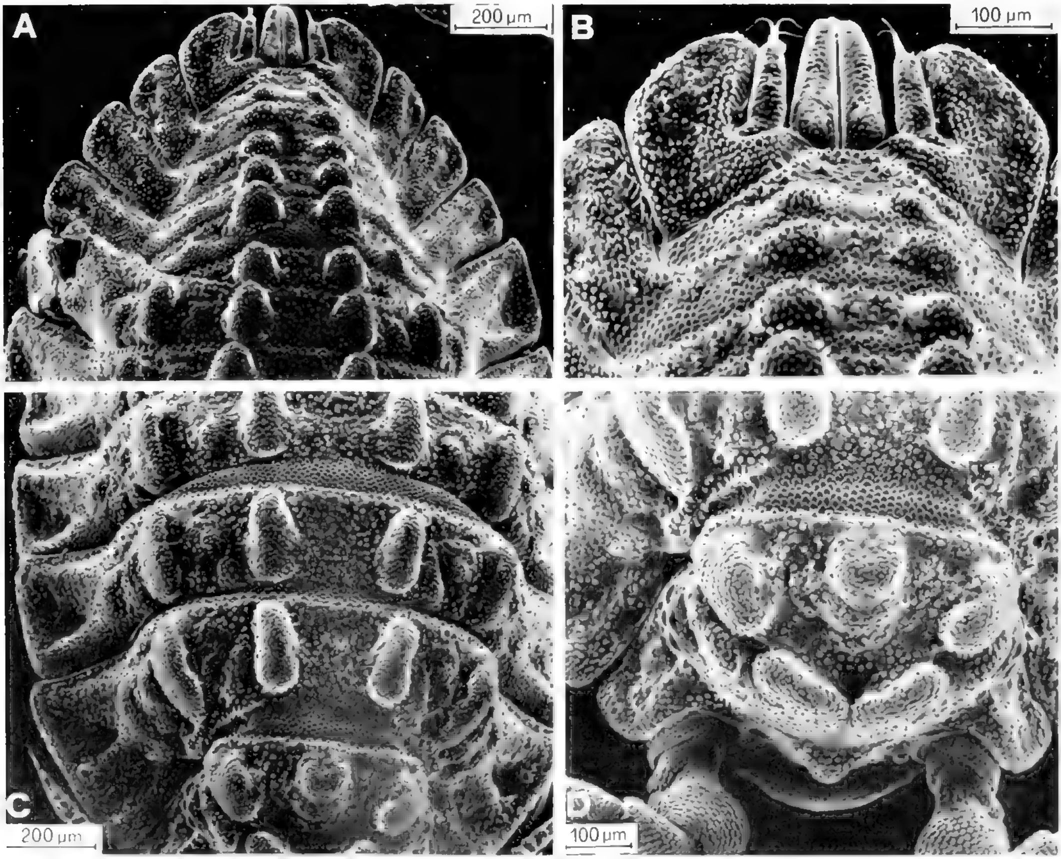

Fig. 10. *Armadilloniscus caraibicus* n. sp. Female: A and B pleon; C and D head and pereon.

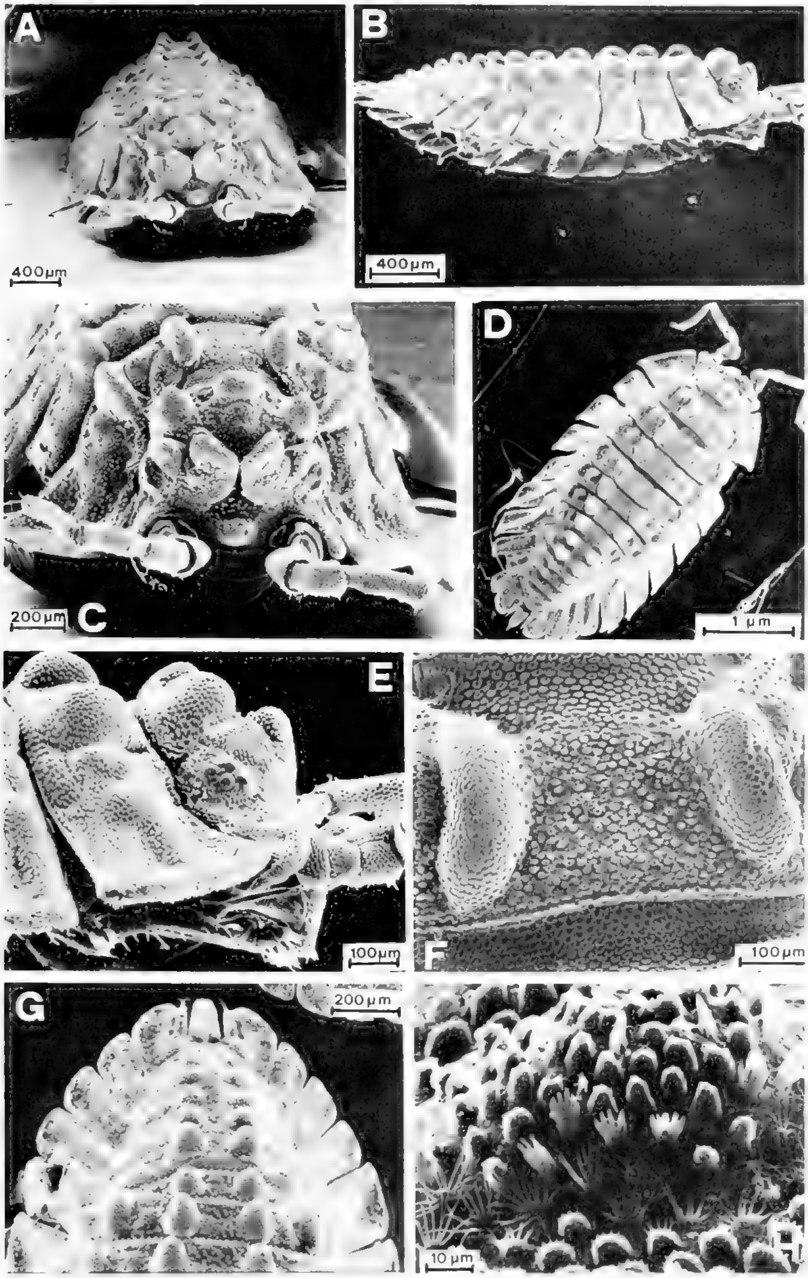

Fig. 11. *Armadilloniscus caraibicus* n. sp. Female: A–D body surface in different perspectives; E head; F pereonite ornamentation; G and H pleon and peculiar tubercle ornamentation.

anterior part (Figs. 10C, D, 11A, C, D, E). Eye with 4–5 visible ommatidia; antenna, without enlargements, holds four flagellar articles, the second with three and the third with two aesthetascs on the inferior surface (Figs. 12C, D); antennule characteristically three-articulated and apically bifurcated; it bears aesthetascs (5 on specimens examined) (Figs. 12A, B).

Body ornamentation: pereon with four

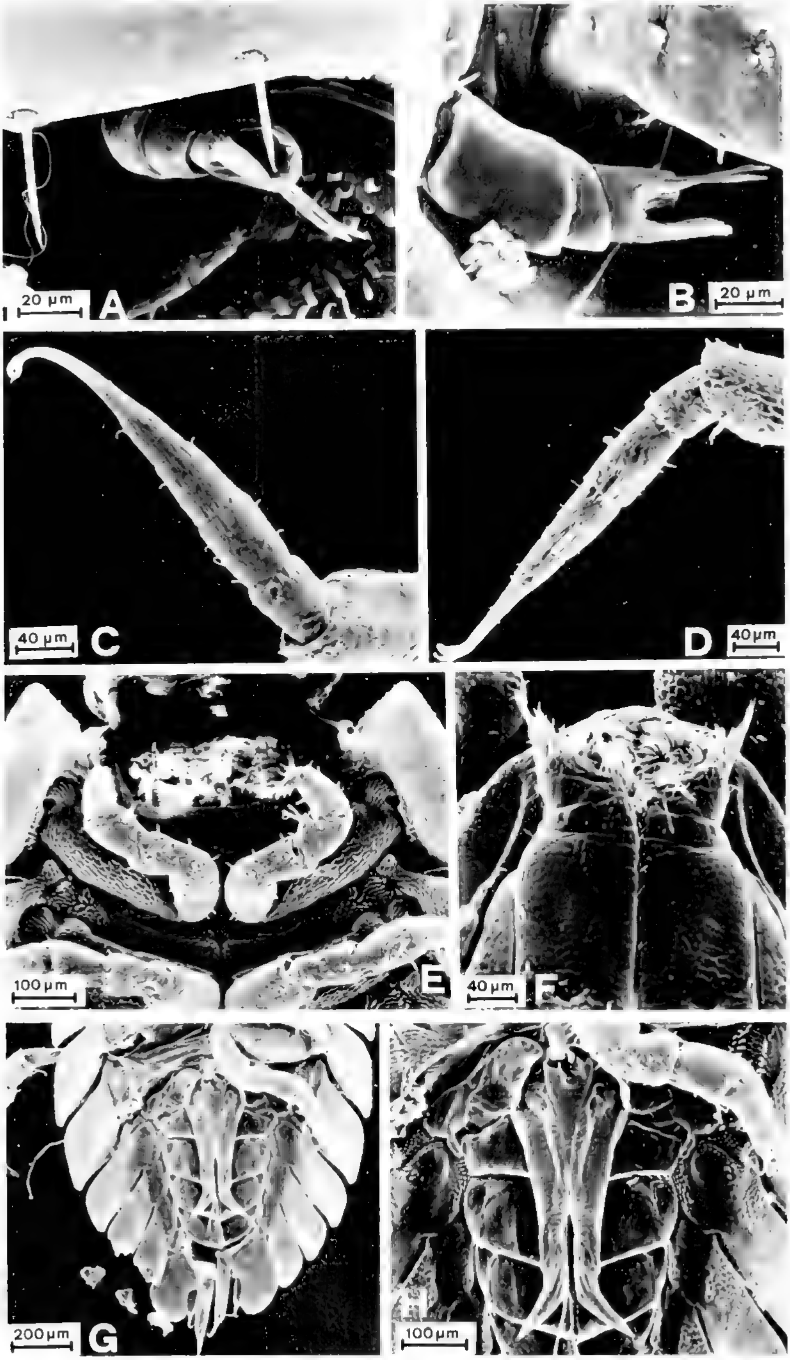

Fig. 12. *Armadilloniscus caraibicus* n. sp. Female A–F. Male G and H. A and B antennules; C and D antennal four-article flagellum in dorsal and ventral view; E forelegs; F maxillipeds; G and H male pleopods I.

main medial ridges and four shallow lateral ridges of tubercles (Figs. 10C, 11A–E); pleon supporting two main ridges of tubercles (Figs. 10A, B; 11B, D, G).

Uropods: endopod somewhat longer than basis, holding a distal spike of 3–4 aesthetascs (Figs. 10B, 11G). Male pereopods I and VII slightly modified (Fig. 5G). Pleopods: male pleopods vary little from other members of the genus (Figs. 5E–F).

Affinities. The development of tubercle ribs on the head, pereon and pleon are the features of *Armadilloniscus caraibicus* n. sp. by which it can easily be differentiated from other species (Arcangeli 1957, Schultz 1972, 1977, Garthwaite et al. 1985). From the more tuberculated *A. coronacapitalis* Menzies, this new species is distinguishable for its smaller size, less tuberculation, differing sculpture on the head, the shape of pleopod I endopod, antennae, and antennules. It can be separated from *Armadilloniscus quadricornis* Vandel, 1971, 1973 by different head structure and ornamentation and by its smaller size.

Habitat. The specimens were found under coralline rocks on the sandy beach in the intertidal zone. Only one specimen was found between woody debris on the beach. The intertidal habitat seems to be the preferred habitat of the genus *Armadilloniscus*.

Distribution and Discussion. *Armadilloniscus caraibicus* n. sp. was found on coralline cays (cayos) of Parque Morrocoy, Venezuela which extends southward in the Neotropical region the distribution of *Armadilloniscus*. A revision of the described species and of Scyphacidae genera is needed to have a better taxonomic and zoogeographic understanding of the group. At present little is known about the phylogenetic relationships of the Scyphacidae and other neotropical isopods.

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# ANTS ASSOCIATED WITH A COLEOPTEROUS LEAF-BUD GALL ON *XYLOPIA AROMATICA* (ANNONACEAE)

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*Abstract.*—We describe the ant fauna (11 species divided into four genera) associated with a coleopterous leaf-bud gall on *Xylopia aromatica* (Annonaceae) in Minas Gerais, Brazil. Ant occupied galls are significantly larger than are unoccupied galls, and the variance of gall diameters for occupied galls is significantly smaller than is the variance for all galls. There is a significant positive relationship between ant colony size and gall diameter. The six most common species of ants may partition galls according to gall size, as there are significant differences in the diameters of occupied galls among species. At the community level, patterns of co-occurrence of ants are indistinguishable from those expected under a random assortment model. Individual ant species do exhibit non-random patterns of co-occurrence.

*Key Words:* Annonaceae, ants, Brazil, coleopterous gall, community ecology, habitat selection, insect galls, Minas Gerais, resource partitioning, *Xylopia aromatica*

Plant galls represent an important resource for many species other than the gall formers. Owing to their localized concentration of nutritive tissues and their marked succulence, galls provide favourable breeding sites for a variety of species (Brandhorst 1962, Mani 1964, Shorthouse 1973, Yukawa 1983). Galls protect their inhabitants from inclement weather (Felt 1940, Uhler 1951, Sandlant 1979; but see Baust et al. 1979) and natural enemies (Askew 1961, 1980, but see Price et al. 1986, 1987). Use of galls ranges from species that open galls simply to prey upon gall formers and inquilines to those that depend exclusively on gall tissues for food and shelter.

Beauvisage (1883, cited in Mani 1964) applied the term "locatari" to species, other than the gall formers, associated with insect galls. Mani (1964) divides the locatari into 33 categories according to their ecological niches. The locatari often represent a vast fauna with the most numerous categories consisting of parasites and predators. For example, Stegagno (1904) reported 177 species associated with cynipid galls on *Quercus* in Italy; of these, 138 are parasites and predators.

Species that inhabit galls after emergence of gall formers and inquilines are the "successori" (Mani 1964, Yukawa 1983). Most of these are plant-nesting ants and myrmecophilous insects, such as aphids and coccids. Others include mites, spiders, thrips, collembola, bees, and wasps (reviewed by Mani 1964). The most common ant genera associated with old galls are: *Camponotus, Cataulacus, Crematogaster,*

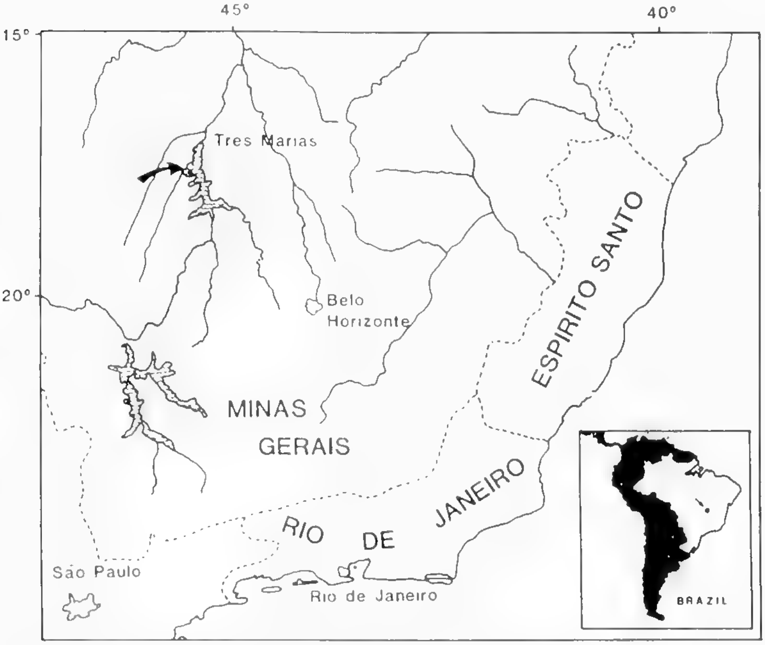

Fig. 1. Location of the Ecological Station of Parapitinga in Três Marias, Minas Gerais, Brasil.

*Colobopsis, Lasius, Leptothorax,* and *Olopsis* (Walsh 1864, Patton 1879, Wheeler 1910, Ping 1920, Sturtevant 1925, Mani 1964, Torossian 1971a, b). Despite their importance and dominance within the successori, little is known about the ecologies of these ants other than compendiums of ant species associated with particular species of gall formers (e.g. Brandhorst 1962, Espadaler and Nieves 1983).

Here, we describe the ant fauna associated with a coleopterous leaf-bud gall on *Xylopia aromatica* (Annonaceae). We describe patterns in distribution and abundance of the ant fauna and document elements of habitat selection and resource partitioning.

## Material and Methods

One of us (G.W.F.) collected galls from the Ecological Station of Parapitinga, Três Marias, Minas Gerais, Brazil during one sample period in mid-May, 1984. The station is a continental island located in a man-made lake (Três Marias Lake) between latitude 18°–19° south and longitude 45°–46° west (Fig. 1).

The host tree, *Xylopia aromatica,* occurred in a gallery forest along the northwest border of the island. Only three individuals of approximately six meters tall bearing galls were observed in the area surveyed. The galls are induced by an unidentified species of curculionid (Coleoptera). Gall formers held as vouchers were kept in the author's collection. The galls are spherical and glabrous and occur on leaf-buds (Fig. 2). They are green when occupied by the gall former, but turn brown after its emergence. All galls which were on trees (n = 114) were collected and subsequently measured and dissected in the laboratory. Galls that fall on the forest floor are also utilized by ants; however they are not included here because of insufficient sample size.

In this paper, we use the word "colony" as any group of ants, composed of workers and larvae (eggs, queen, and pupae if pres-

Fig. 2. Coleopterous leaf-bud galls found on *Xylopia aromatica.* Gall diameter ranged from 5.0 to 21.5 mm.

ent), occupying a single gall. In addition, we defined those galls in which we found only workers as "groups of workers."

### STATISTICAL ANALYSES

We compared the mean diameter of galls that were occupied by ants with the mean diameter of unoccupied galls using one-way analysis of variance. We also compared the variance of occupied galls with the variance of all galls (including occupied galls) with a Chi-square test (Sokal and Rohlf 1969, page 175). We assumed that our collection consisted of the entire population of galls on the island and that the set of occupied galls was a sample from that population.

Table 1. Ant species associated with coleopterous leaf-bud galls on *Xylopia aromatica* (Annonaceae).

| Ant Species | Number of Colonies | $(\bar{x})$ Individuals | | Gall Diameter $(\bar{x})$ mm |
|---|---|---|---|---|
| | | Adult | Larvae/Pupae | |
| *Azteca bicolor* | 1 | 1.0 | — | 14.5 |
| *Azteca* sp. | 17 | 28.1 | 8.9 | 16.4 |
| *Leptothorax wilda* | 13 | 5.4 | 4.6 | 14.7 |
| *Leptothorax* sp. | 1 | 45.0 | 37.0 | 17.0 |
| *Pseudomyrmex flavidus* | 4 | 0.8 | 5.5 | 16.4 |
| *Pseudomyrmex* sp. A | 1 | 1.0 | — | 12.5 |
| *Pseudomyrmex* sp. B | 1 | 1.0 | — | 15.0 |
| *Zacryptocerus pallens* | 7 | 2.0 | — | 12.9 |
| *Zacryptocerus pusillus* | 8 | 51.3 | 12.5 | 15.9 |
| *Zacryptocerus* sp. A | 11 | 5.7 | 2.2 | 14.9 |
| *Zacryptocerus* sp. B | 1 | 4.0 | 4.0 | 10.0 |

We compared the mean diameters of occupied galls among the six most common species of ants by one-way analysis of variance.

We estimated the relationship between the logarithm of colony size (number of individuals, of all castes, in a gall) and gall diameter through linear regression.

Finally, we examined patterns of occurrence within galls. We compared the number of galls that contained 0, 1, 2, and 3 species of ants with those expected under a Poisson distribution. We estimated $\lambda$, the Poisson parameter, from the sample. We compared the observed distribution to the expected distribution with a Chi-square goodness-of-fit test.

## RESULTS

We collected 114 galls of which 52 (45.6%) were occupied by ants. Eleven species of ants were represented in the sample; the most common were *Azteca* sp. which occupied 17 galls, *Leptothorax wilda* which occupied 13 galls, and *Zacryptocerus* sp. "A" which occupied 11 galls (Table 1). Five species were represented by a single individual. "Colony sizes" ranged from three individuals to a colony of *Zacryptocerus pusillus* which contained 129 adults and larvae.

The internal structure of the galls was highly modified in some cases, unmodified in others (Fig. 3). Modification is defined as any internal architectural departure, such as tunnel and gall wall holes, from the usual spheroid larval chamber. In particular, galls inhabited by *Azteca* sp. and *Zacryptocerus pusillus* exhibited extensive modifications when compared to unmodified galls. Galls inhabited by *Pseudomyrmex flavidus* were unmodified. Modified galls typically contained larger colonies than did unmodified galls.

Ants typically occupied large galls (Fig. 4). The mean diameter of occupied galls, 15.6 mm, was significantly larger than the mean diameter of unoccupied galls, 13.6 mm ($F_{1,112} = 12.8$, $P < 0.001$). The variance of diameters of occupied galls was significantly smaller than would be expected if ants were selecting galls at random ($\chi^2_{113} = 72.1$, $P < 0.005$).

There was a significantly positive linear relationship between the logarithm of colony size (number of individuals) and gall diameter (Fig. 5).

The six more common species of ants further partitioned the subset of occupied galls according to gall size; mean gall diameters of occupied galls were significantly different among species ($F_{5,54} = 2.74$, $P < 0.05$). *Azteca* sp. typically occupied the largest galls ($\bar{x} = 16.4$ mm), *Zacryptocerus pallens* the smallest ($\bar{x} = 12.9$ mm).

We collected 65 colonies distributed

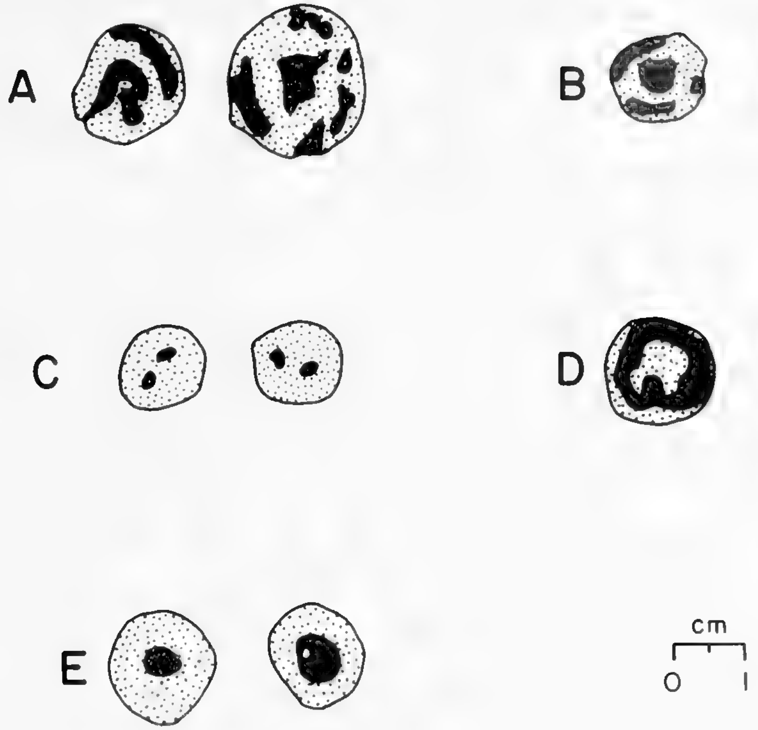

Fig. 3. Cross-sections of galls showing internal modifications by ants. Gall (A) contained *Azteca* sp., (B) *Leptothorax* sp., (C) *Zacryptocerus pallens*, (D) *Zacryptocerus pusillus*, and (E) *Pseudomyrmex flavidus*.

among 114 galls. We estimated λ, the Poisson parameter, as 65/114 = 0.57. The observed distribution of colonies among galls closely resembled the expected under a Poisson distribution (Table 2). The goodness-of-fit test indicated no significant difference between the observed and expected distributions ($\chi^2_3 = 2.51$, $P > 0.10$).

Individual species did exhibit frequencies of co-occurrence that appeared different from those expected by chance alone (Table 3). For example, *Zacryptocerus pusillus*

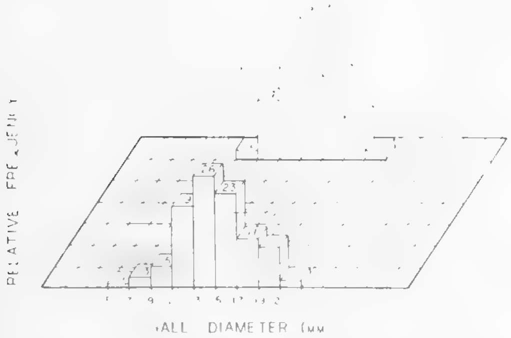

Fig. 4. Relative frequency histograms of gall diameter for the entire set of galls (foreground) and for the subset of galls that were occupied by ants (background).

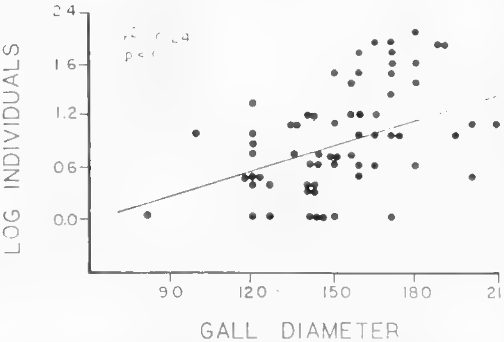

Fig. 5. Relationship between the logarithm of colony size (number of individuals) and gall diameter. The relationship is $\hat{Y} = -0.929 + 0.122\hat{X}$ ($F_{1,63} = 20.1$, $P < 0.001$; $R^2 = 0.24$).

Table 2. Distribution of colonies among galls. Expected values are based on a Poisson distribution with $\lambda = 0.57$.

| Colonies/Gall | Observed | Expected |
|---|---|---|
| 0 | 62 | 64.5 |
| 1 | 42 | 36.8 |
| 2 | 7 | 10.5 |
| 3 | 3 | 2.0 |

never jointly occupied a gall, while approximately 4 such co-occurrences would be expected at random. *Azteca* sp. and *Leptothorax wilda* were roughly half as likely to co-inhabit a gall as chance alone would predict. On the other hand, *Zacryptocerus pallens* exhibited a slight tendency to share galls.

## Discussion

Galls represent an important resource for this ant community, and ants exploit this resource in a non-random fashion. Ants select significantly larger galls, over a narrower range of sizes, than chance alone would predict. Both the difference in means and the difference in variance indicate habitat selection. There may be strong selective pressures for this habitat selection as indicated by the significant positive relationship between colony size and gall size. Selection of larger galls by ants may be due to several reasons, among them increase in queen fitness. However, more work is called for to observe the selection and the use of larger versus smaller galls.

It is not clear whether galls are a limiting resource to these ants. On the other hand, the most common species of ants exhibited resource partitioning. This is a necessary condition for stable coexistence of multi-species assemblages exploiting similar, limiting resources predicted by Lotka-Volterra based analyses of community dynamics (May 1973, Schoener 1974). Of course, neither observation by itself is conclusive. Unoccupied galls may be the result of interference competition or priority effects (sensu Torres 1984). Significant differences among species in the diameters of occupied galls may not be the result of competitively induced resource partitioning, but rather, species' idiosyncratic responses to their environment (James et al. 1984). Correlative data provide notoriously weak inferences regarding mechanisms (Brady 1979); experiments are required to establish causation.

Table 3. Patterns of co-occurrences among ant species.

| Species | Joint Occurrences | |
|---|---|---|
| | Observed | Expected |
| *Azteca bicolor* | 1 | 0.58 |
| *Azteca* sp. | 4 | 7.15 |
| *Leptothorax wilda* | 3 | 5.93 |
| *Leptothorax* sp. | 0 | 0.58 |
| *Pseudomyrmex flavidus* | 3 | 2.13 |
| *Pseudomyrmex* sp. A | 1 | 0.58 |
| *Pseudomyrmex* sp. B | 0 | 0.58 |
| *Zacryptocerus pallens* | 5 | 3.54 |
| *Zacryptocerus pusillus* | 0 | 3.99 |
| *Zacryptocerus* sp. A | 5 | 5.19 |
| *Zacryptocerus* sp. B | 0 | 0.58 |

Patterns of species co-occurrence at the community level are indistinguishable from those predicted from a random assortment model. However at the constituent level, individual species deviate from expectation. In particular, *Zacryptocerus pusillus* never shares a gall, although approximately four joint occurrences are predicted. Fowler et al. (1985) provide evidence that *Z. pusillus* is interspecifically territorial. Whether deviations from chance for the other species are biologically significant is unclear. Unfortunately, little is known about the ecologies of these ants.

Gall-inhabiting ants may provide an ideal system to examine the determinants of community organization in arboreal ants. Galls are a discrete resource, amenable to experimental manipulation in time and space.

## Acknowledgments

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# REVISION OF THE *ORNATUS* SPECIES GROUP OF THE GENUS *ANTHONOMUS* GERMAR (COLEOPTERA: CURCULIONIDAE)

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*Abstract.*—The seven species in the *Anthonomus ornatus* species group are *A. ornatus* Blanchard, *A. signatipennis* Blanchard, ***A. chilicola* Clark, new species, *A. kuscheli* Clark, new species, *A. araucanus* Clark, new species, *A. blanchardi* Clark, new species**, and ***A. berberidis* Clark, new species**. These are hypothesized to constitute a monophyletic group on the basis of morphological characters of the adult weevils, their common association with plants in the genus *Berberis* (Berberidaceae) and their restricted distributions in southern Chile and Argentina. Other characters determined to be apomorphic by comparisons with other anthonomines were used to produce a phylogeny of the species in the *A. ornatus* group. Characters diagnostic of the group and of each of the species are presented, along with illustrations and a key to adults of the species. The larval and pupal stages of *A. ornatus* and *A. kuscheli* are also described and illustrated.

*Key Words:* *Anthonomus*, Anthonominae, PAUP, phylogeny, *Berberis*, Chile, Argentina

The *Anthonomus ornatus* group includes *A. ornatus* Blanchard, *A. signatipennis* Blanchard, and five heretofore undescribed species. The species occur in southern Chile and Argentina at least as far south as Isla Navarino (55°S) in the Chilean province of Magallanes northward to the province of Coquimbo (30°S). Known hosts of the species are plants in the genus *Berberis* (Berberidaceae). The members of the *A. ornatus* group appear to be the only representatives of the subfamily Anthonominae in Chile. This fact is noteworthy because the anthonomines are rich and diverse in the remainder of the Neotropical Region (O'Brien and Wibmer 1982, Wibmer and O'Brien 1986). It seems likely that the sister group of the *A. ornatus* group will be found among the Nearctic or Neotropical species, but hypotheses of such relationships cannot be formulated until these species are more completely known taxonomically. Meanwhile, the descriptions, illustrations and keys presented in this paper should facilitate identification of the species in the *A. ornatus* group.

## MATERIALS AND METHODS

Specimens of 785 adults, including the types of the previously described species, were examined. These were from the collections of the following individuals and institutions (letter codens identify the collections in the text):

| | |
|---|---|
| AMNH | The American Museum of Natural History, New York City, New York, USA (L. H. Herman, Jr.); |
| CACA | Collection of Allan C. Ashworth, Fargo, North Dakota, USA; |
| CCBM | Collection of C. Bordón, Maracay, Venezuela; |

| | |
|---|---|
| CWOB | Collection of C. W. O'Brien, Tallahassee, Florida, USA; |
| HAHC | Collection of H. and A. Howden, Ottawa, Ontario, Canada; |
| MCZC | Museum of Comparative Zoology, Cambridge, Massachusetts, USA (S. R. Shaw); |
| MNHN | Muséum National d'Histoire Naturelle, Paris, France (H. Perrin); |
| MNNC | Museo Nacional de Historia Natural, Santiago, Chile (M. Elgueta D.); |
| MZSP | Museu de Zoología, Universidade de São Paulo, São Paulo, Brazil (U. R. Martins); |
| NZAC | Division of Scientific and Industrial Research, Auckland, New Zealand (G. Kuschel); |
| TAMU | Texas A&M University, College Station, Texas, USA (H. R. Burke); |
| USNM | National Museum of Natural History, Washington, D.C., USA (D. R. Whitehead). |

Measurements of adult specimens were made with an ocular micrometer in a dissecting microscope as follows: total length from anterior margin of eye to elytral apex in lateral view; width across elytra at widest point; length of pronotum, dorsally, from anterior to posterior margins; length of rostrum from anteroventral margin of eye to apex, across arc, in lateral view; length of distal portion of rostrum from antennal insertion to apex in lateral view; width of frons at narrowest point between eyes; width of base of rostrum just distad of eyes in dorsal view; and width of pro- and metafemora, in anterior view, excluding the ventral teeth. The range and, in parentheses, the mean and sample size of each measurement are given for each species.

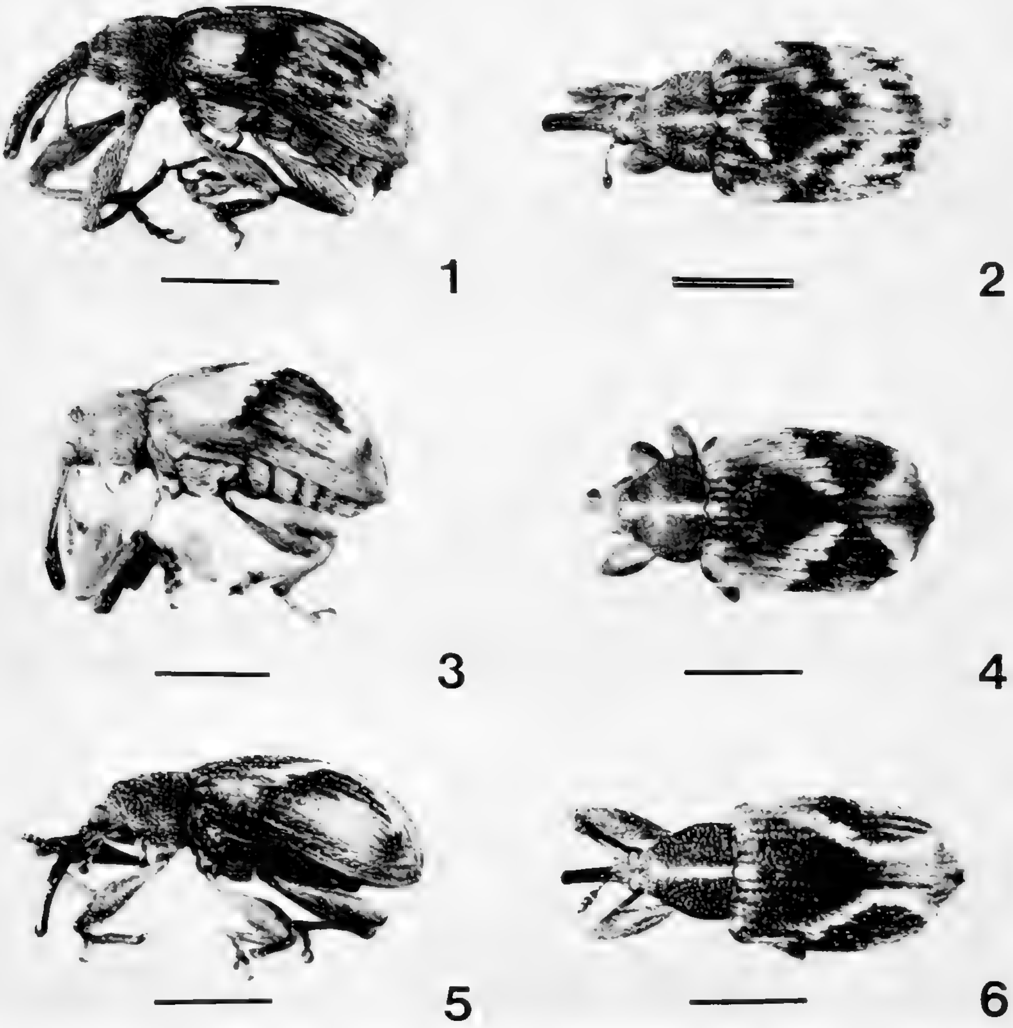
Descriptions of larvae are based on full-grown specimens. The terminology follows Anderson (1947) and Thomas (1957). Where differences in terminology exist between the two systems, the Thomas terms are placed in parentheses following those of Anderson. Terminology of pupal characters follows Burke (1968).

### THE *ANTHONOMUS ORNATUS* GROUP

Adults of the seven species in the *A. ornatus* group are about average in size for the genus (specimens examined range from 1.88 to 4.00 mm in length), somewhat elongate and slender in body form, without significant elytral prominences, and with relatively slender profemora armed with a moderately large ventral tooth and a smaller, distal tooth. They are distinguished by their contrasting patterns of white, pallid to dark ferruginous and fuscous scales that cover corresponding areas of pallid or dark integument (Figs. 1–12). No other anthonomines examined have exactly this same pattern. Adults of the species also have an elongate, flat, distal endophallic sclerite (Figs. 19–30). They are further characterized as follows:

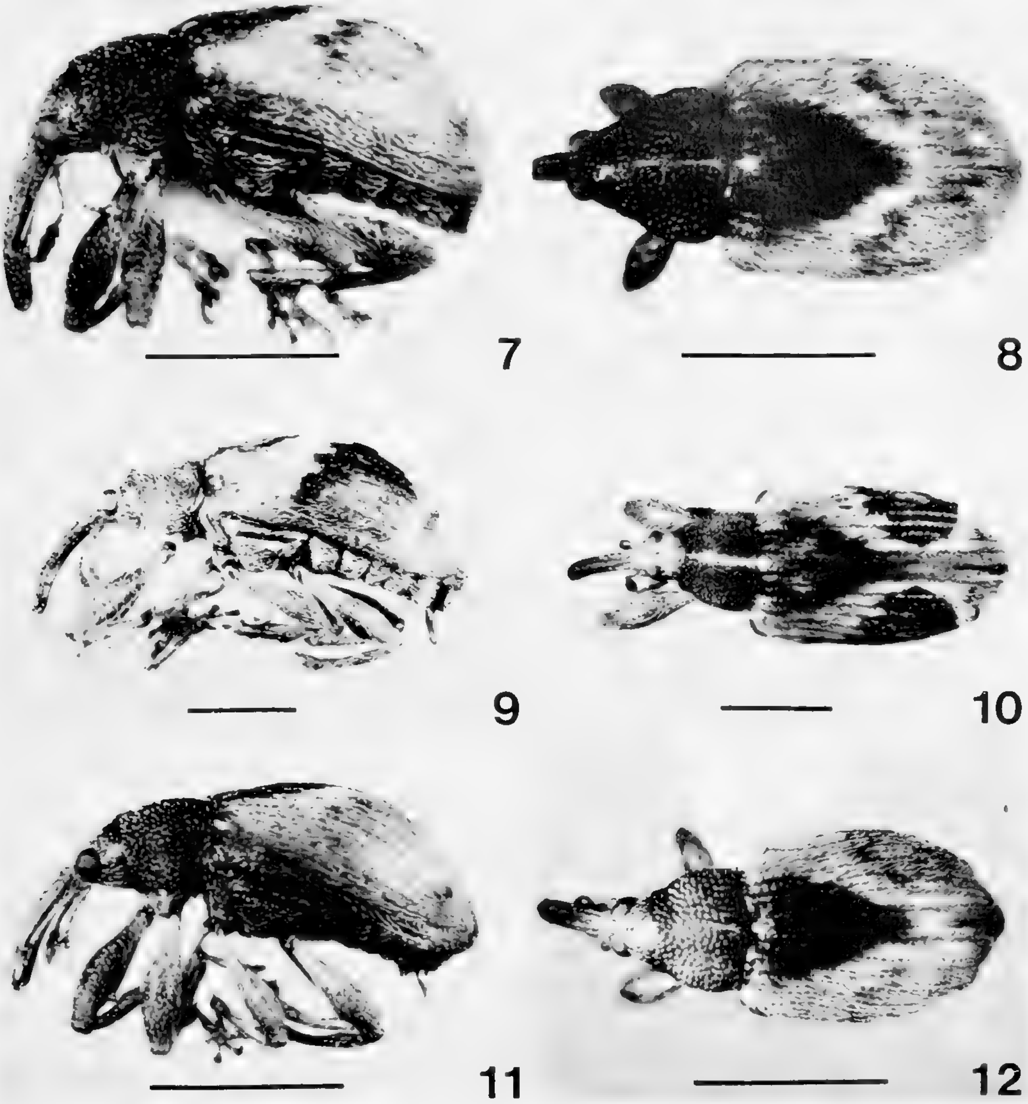
*Head:* vertex with narrow ferruginous scales, frons with broader, more pallid scales; eyes strongly convex, slightly to prominently elevated, separated by distance 0.6–0.9 × width of rostrum at base; antennal funiculus with 7 articles. *Rostrum:* slender; proximal portion with well-developed carinae and sulci; finely setose. *Prothorax:* pronotum densely, coarsely punctate, with narrow, attenuate, pallid to dark ferruginous scales and broader, more pallid scales in narrow middorsal vitta; pleuron with small anteromedian patch of pallid, broad scales that is feebly developed in small specimens. *Elytra:* humeri not prominent; sides subparallel. *Pygidium:* not impressed or sulcate. *Legs:* pro- and mesocoxae with dense, broad, pallid scales that are weakly developed in small specimens; profemur slender, ca. 1.1–1.2 × stouter than metafemur, with small, conical, acute ventral tooth and smaller distal tooth; metafemur with small ventral tooth and minute distal tooth; protibial uncus slender, slightly curved. *Genitalia:* male tegmen with long parameres.

Distribution (Figs. 42–45). The species in the *A. ornatus* group are known mainly from



Figs. 1–6. Habitus of adults (lines represent 1 mm): 1) *A. signatipennis*, male, Quinta Pittet, Magallanes, Chile, lateral view; 2) the same, dorsal view; 3) *A. ornatus*, male, Rio El Ganso, Seno de Otway, Magallanes, Chile, lateral view; 4) the same, dorsal view; 5) *A. kuscheli*, female, Chepu, Chiloé, Chile, lateral view; 6) the same, dorsal view.

the Valdivian and Magellanic forest regions which, according to Kuschel (1960), extend south of the 36th parallel beyond the southernmost portion of the continent to Isla Navarino at the 55th parallel. Blanchard (1851: 387) stated that both *A. signatipennis* and *A. ornatus* were found in "la provincia de Coquimbo." These records, along with records of *A. signatipennis* from the Chilean provinces of Valparaíso and Santiago (Figs. 42, 43), extend the limits of the group significantly north of the Valdivian Forest into more arid regions. A possible explanation for this extension is found in the observation by Davis (1986) that in parts of the Coquimban Desert Province, moisture from coastal fog supports remnants of the Valdivian forest. Davis listed several southern

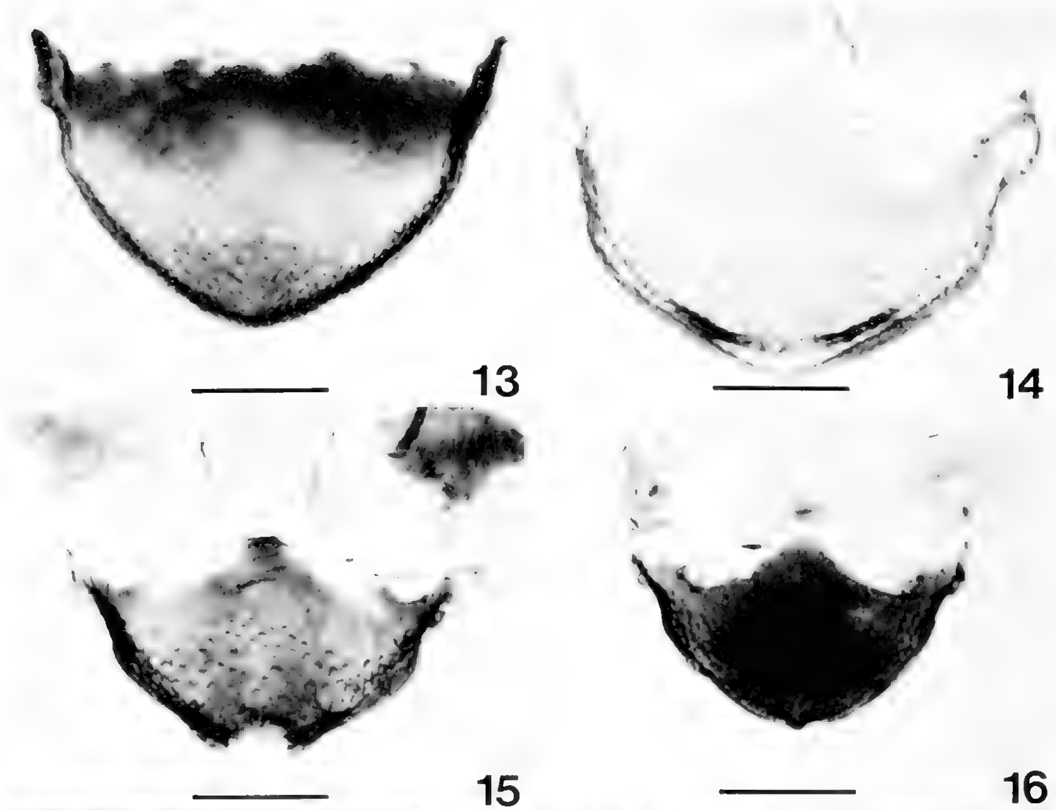


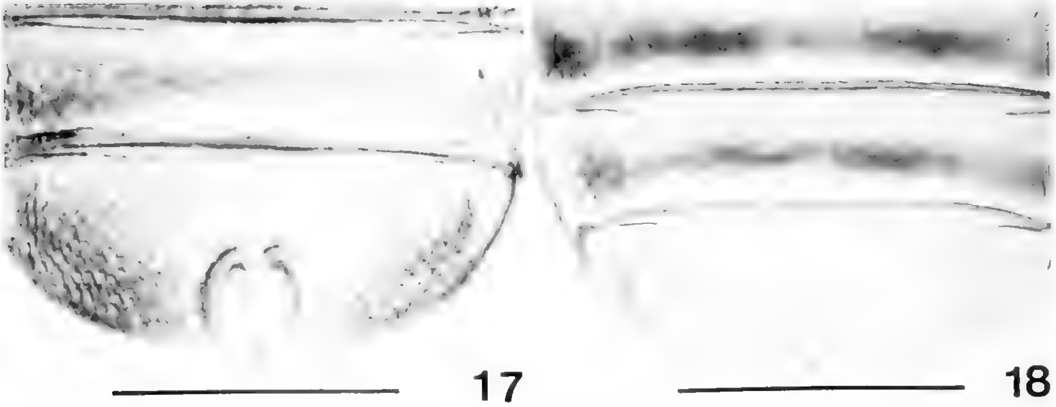
Figs. 7–12. Habitus of adults (lines represent 1 mm): 7) *A. araucanus,* male, Laguna Malleco, Malleco, Chile, lateral view; 8) the same, dorsal view; 9) *A. chilicola,* male, 20 km. E Manzanar, Malleco, Chile, lateral view; 10) the same, dorsal view; 11) *A. berberidis,* male, Frutillar, Llanquihue, Chile, lateral view; 12) the same, dorsal view.

temperate plant species (not including *Berberis,* the known hosts of the members of the *A. ornatus* group), as occurring in these moist refugia.

Plant associations. Six of the 7 species of the *A. ornatus* group are known to be associated with one or more of the following Berberidaceae: *Berberis buxifolia* Lamarck; *B. chilensis* Hort. *ex* C. Koch; *B. darwini* Hooker; and *B. ilicifolia* Forster in Comm. The two species for which the immatures are known, *A. ornatus* and *A. kuscheli,* develop in flower buds. The site of development of the remaining species is not known.

Label data indicate that adults of *A. signatipennis* and *A. ornatus* have been col-

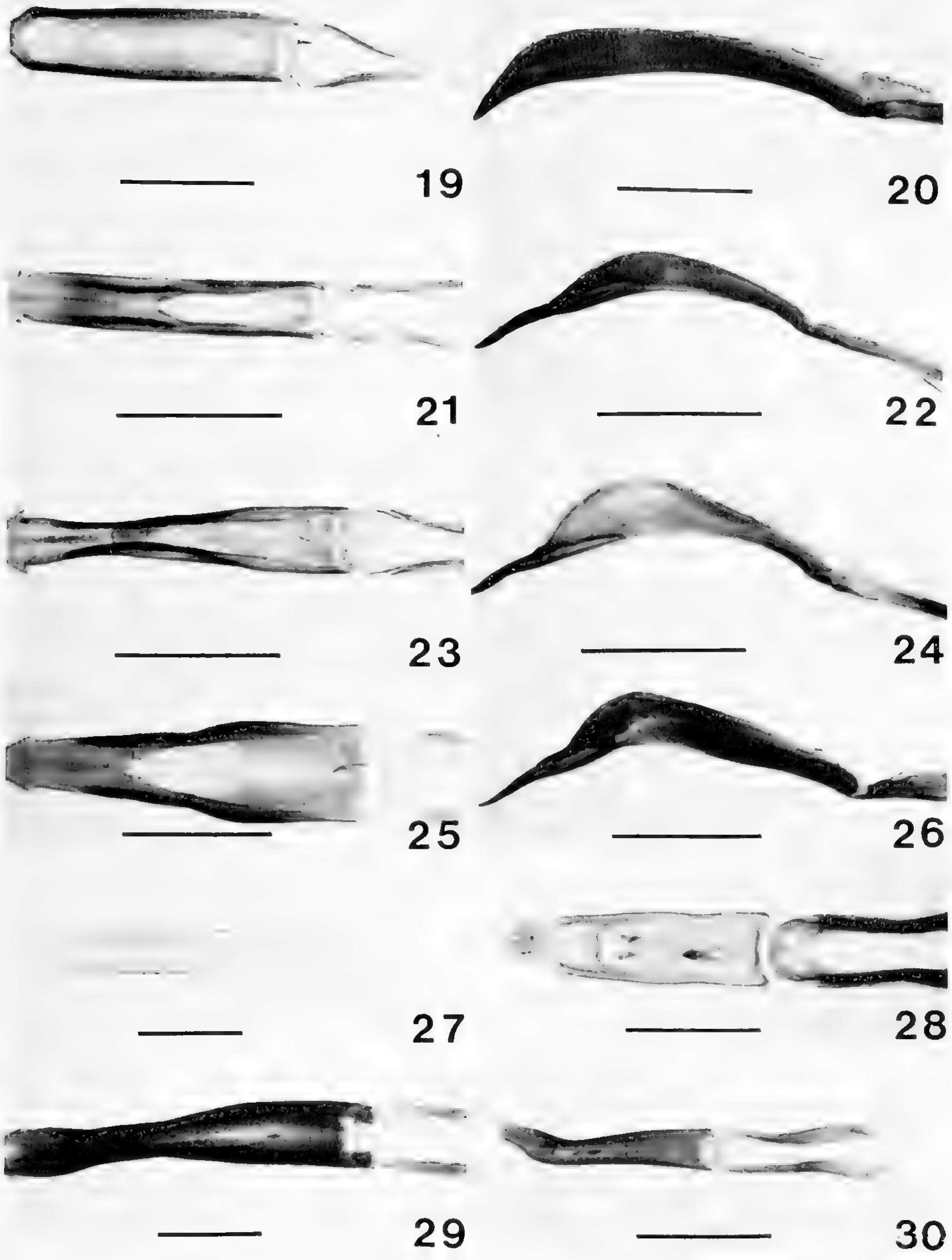




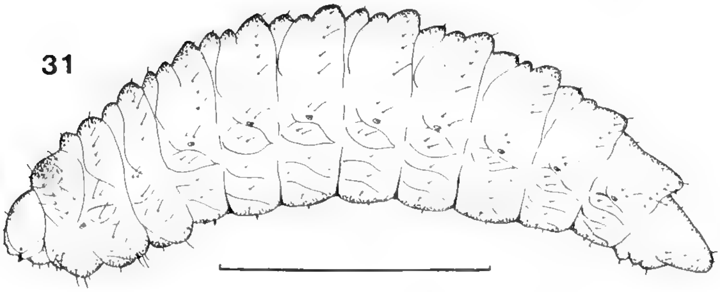
Figs. 13–16. Pygidium, adult female, dorsal view (line represents 0.25 mm): 13) *A. signatipennis,* Quinta Pittet, Magallanes, Chile; 14) *A. ornatus,* Lago Frio, Aisén, Chile; 15) *A. kuscheli,* Panquipulli, Valdivia, Chile; 16) *A. araucanus,* Laguna Laja, Bío-Bío, Chile.

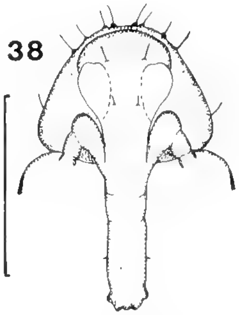
Figs. 17–18. Abdomen, adult female, ventral view (line represents 0.25 mm): 17) *A. ornatus,* Lago Frio, Aisén, Chile; 18) *A. blanchardi,* El Coigo, Curicó, Chile.

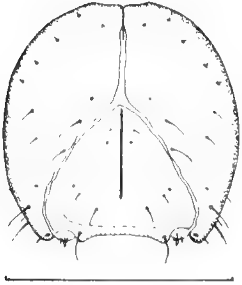
lected together, on the same date, at several localities. One of these records indicates that specimens of the two species were taken on the same day on *B. buxifolia.* Larvae of one of the species, *A. ornatus,* are known to develop in flower buds, but the developmental site of *A. signatipennis* is unknown. Adults of the two species have also been taken at the same locality on *B. ilicifolia,* but one day apart. Adult *A. blanchardi* have been

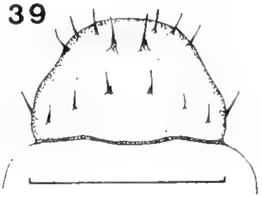


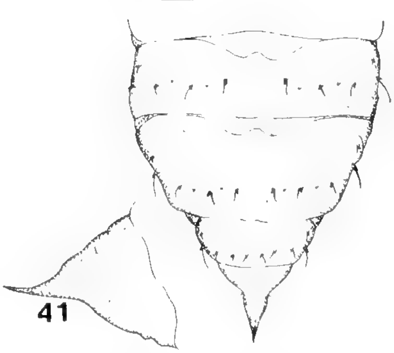
Figs. 19–30. Aedeagus, adult male (line represents 0.5 mm): 19) *A. signatipennis*, Estancia Fenton, Magallanes, Chile, dorsal view; 20) the same, lateral view; 21) *A. ornatus*, Trapatrapa, Concepción, dorsal view; 22) the same, lateral view; 23) *A. ornatus*, Lago Frio, Aisén, dorsal view; 24) the same, lateral view; 25) *A. blanchardi*, El Coigo, Curicó, Chile, dorsal view; 26) the same, lateral view; 27) *A. kuscheli*, Pichinahuel, Malleco, Chile, dorsal view; 28) *A. araucanus*, 20 km. E Manzanar, Malleco, Chile, dorsal view; 29) *A. chilicola*, 20 km. E Manzanar, Malleco, Chile, dorsal view; 30) *A. berberidis*, Frutillar, Llanquihue, Chile, dorsal view.









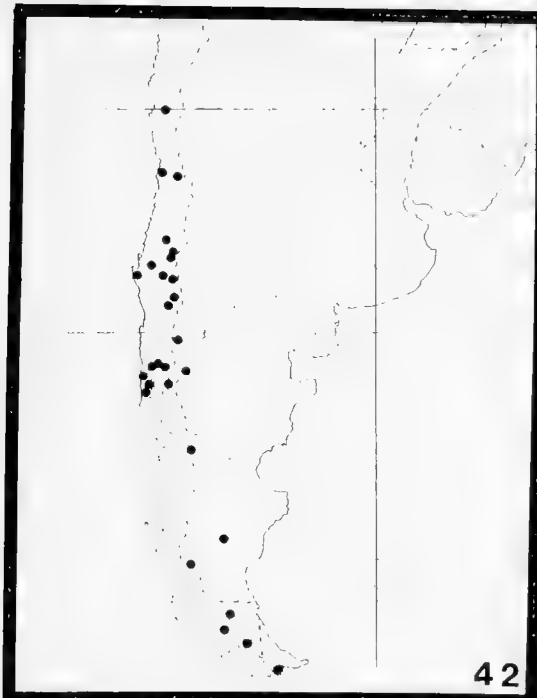


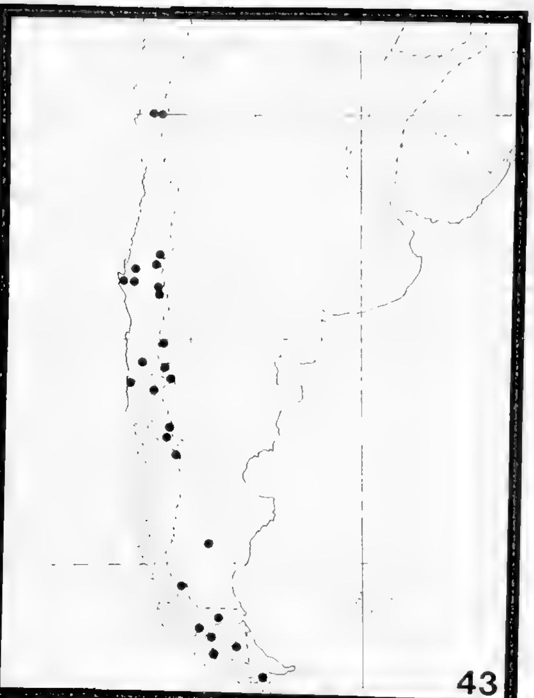
Figs. 31–37. Third instar larva of *Anthonomus kuscheli.* 31) lateral view; 32) head capsule, frontal view; 33) labium and right maxilla, ventral view; 34) epipharynx; 35) clypeus and labrum; 36) abdominal segments 3 and 4, dorsal view; 37) mandible. Line accompanying Fig. 31 = 2 mm; Fig. 32 = 0.5 mm; Fig. 33 = 0.25 mm; other figures greatly enlarged.

Figs. 38–41. Pupa of *Anthonomus ornatus.* 38) head, rostrum and ventral view of prothorax; 39) prothorax, dorsal view; 40) terminal abdominal segments, dorsal view; 41) 9th abdominal segment; lateral view. Line accompanying Fig. 38 = 1 mm; Fig. 39 = 1 mm; Fig. 40 = 0.5 mm.

collected on *B. buxifolia,* but not at the same locality as *A. signatipennis* and *A. ornatus.* Adults of another pair of species, *A. kuscheli* and *A. berberidis,* have been collected on *B. darwini* at the same time and locality.

Discussion. No observed characters of adults of the members of the *A. ornatus* group can be cited with confidence as evidence of a sister group relationship with any anthonomine group (Clark 1987a, b, c, 1988, Clark and Burke 1985, 1986a, b, c, Clark and Martíns 1987). The larvae of two of the species, *A. ornatus* and *A. kuscheli,* are known. These larvae trace to *A. pomorum* L. and *A. nebulosus* LeConte in a key to larvae of members of the subfamily (Ahmad and Burke 1972), but there is no other indication that these species are very closely related. Larvae of *A. kuscheli* are distinct in possessing three rather than four epipharyn-


42


43

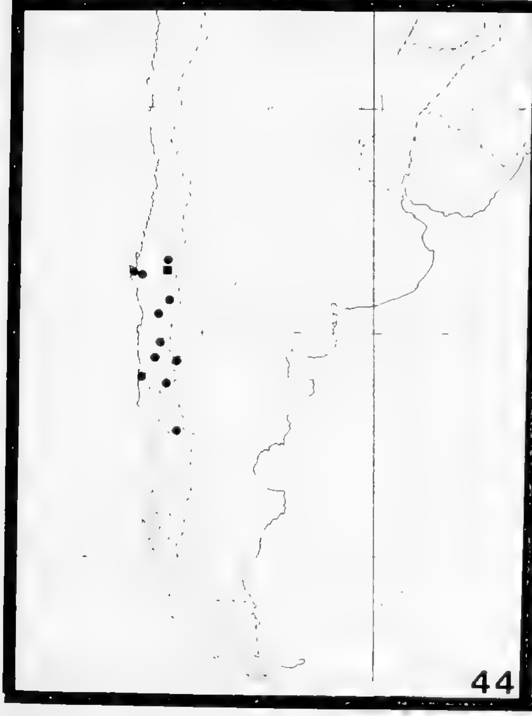

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Fig. 42. Map of southern South America showing the distribution of *A. signatipennis*.

Fig. 43. Map of southern South America showing the distribution of *A. ornatus*.

Fig. 44. Map of southern South America showing the distributions of *A. kuscheli* (circles) and *A. chilicola* (square).

Fig. 45. Map of southern South America showing the distributions of *A. blanchardi* (circles), *A. araucanus* (triangles) and *A. berberidis* (squares).

geal sensory pores. Larvae of *Coccotorus scutellaris* (LeConte) are the only other anthonomines known to have only three epipharyngeal sensory pores, but available information does not indicate that this species is closely related to the *A. ornatus* group. The pupae of members of the *A. ornatus* group have a single process on the 9th abdominal segment. This structure, however, is also shared with several other, apparently unrelated anthonomines, including *Tachypterellus quadrigibbus* Say, *Pseudanthonomus validus* Dietz, *Anthonomus albopilosus* Dietz, *A. stupulosus* Champion, *A. griseisquamis* Champion, *A. unipustulatus* Champion and *A. nubiloides* Fall (Burke 1968).

The association of the species in the *A. ornatus* group with plants in the genus *Berberis* is biogeographically significant. Guillermo Kuschel (pers. comm.), speaking from years of experience collecting weevils and other insects in Chile and neighboring countries, noted that the *A. ornatus* group members were found exclusively on *Berberis*. He also insisted that he "frequently and quite thoroughly" checked *Berberis* plants all over northern Chile, Peru and Bolivia, but found no anthonomines on those plants there. The ±500 species of *Berberis* are distributed throughout the north temperate zones and southward, mainly at higher altitudes, in tropical regions of Africa, Asia and South America (Cronquist 1981: 130, Good 1964: 80–81). As noted by Cabrera and Willink (1973: 98), species of *Berberis* are abundant in the Valdivian and Magellanic forests of southern Chile and adjacent portions of Argentina. Raven (1963: 155) listed *Berberis* among several genera that used the mountains to extend their distribution from the northern hemisphere to the south. No other anthonomines are known to have hosts in the family Berberidaceae (Burke [1976] listed plant families known to contain anthonomine hosts).

It is fairly certain that the members of the *A. ornatus* group are the only anthonomines to be found in Chile. No others are listed by Wibmer and O'Brien (1986) in their checklist of South American Curculionidae. Schenkling and Marshall (1934) did list two other Chilean Curculionidae, *Anthonomus variabilis* Philipi and *A. australis* Philipi, as anthonomines, but Kuschel (1950: 17) determined that these are actually members of the genus *Rhopalomerus* Blanchard in the subfamily Eugnominae.

## KEY TO ADULTS OF THE SPECIES OF *ANTHONOMUS* IN THE *A. ORNATUS* GROUP

1. Elytra (Figs. 1, 2) with oblique, alternating light and dark fasciae, without posterolateral maculae; elytral interstria 2 with discrete posteromedian pallid line bounded anteriorly and posteriorly by short, dark portions (Figs. 1, 2) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *signatipennis*

1′. Elytra with large, posterolateral maculae (Figs. 3–6, 9, 10) (feebly developed in some specimens, Figs. 7, 8, 11, 12); elytral interstria 2 without discrete posteromedian pallid segment bounded anteriorly and posteriorly by short, dark portions . . . . . . . . . . . . . . . . . . . . . . 2

2. Sutural elytral interstriae with acute, overlapping apical extensions; metatibia of male with ventral margin strongly concave in distal ⅔, with enlarged, excavated apical mucro; aedeagus asymmetrical (Figs. 29, 30) . . . . . . . . . . . . 3

2′. Sutural elytral interstriae without apical extensions; metatibia of male with ventral margin not or only slightly concave in distal ⅔, apical mucro small; aedeagus symmetrical (Figs. 19–28) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4

3. Sternum 5 of male with large posteromedian prominence (Fig. 11); pallid annuli around posterolateral elytral maculae weakly developed (Fig. 12) . . . . . . . . . . . . . . . . . . . . . . *berberidis*

3′. Sternum 5 of male without posteromedian prominence; pallid annuli around posterolateral maculae distinct (Fig. 10) . . . . . . *chilicola*

4. Elytra with posterolateral maculae completely surrounded dorsally by pallid annuli (Figs. 5, 6); pygidium of female with subapical prominences (Fig. 15); body slender, somewhat flattened dorsally (Fig. 5) . . . . . . . . . . . . . . . . *kuscheli*

4′. Elytra with posterolateral maculae incompletely surrounded dorsally by pallid annuli (Figs. 3, 4), *or* macula feebly developed (Figs. 7, 8); pygidium of female with subapical prominences weakly developed (Fig. 14) or absent; body less slender, less flattened (Figs. 3, 7) . . 5

5. Elytral pattern distinct (Figs. 3, 4); sternum 5 of female with shallow emarginations (Fig. 18) *or* deep incisions (Fig. 17) on each side of me-

dian prominence; aedeagus with apicolateral prominences (Figs. 21, 23, 25); pygidium of female without apicomedian prominence (Fig. 14) . . . . . . . . . . . . . . . . . . . . . 6

5′. Elytral pattern weakly developed, except for prominent midbasal macula (Figs. 7, 8); sternum 5 of female without emarginations or incisions; apex of aedeagus narrowed to apex, without apicolateral projections (Fig. 28); pygidium of female with small apicomedian prominence (Fig. 16) . . . . . . . . . . . . . . . *araucanus*

6. Sternum 5 of female with deep posteromedian incisions (Fig. 17); aedeagus (Figs. 21, 23) about as broad at broadly rounded apex as at base, with acutely pointed apicolateral prominences . . . . . . . . . . . . . . . *ornatus*

6′. Sternum 5 of female (Fig. 18) with small, shallow emarginations on each side of small, blunt, posteromarginal prominence; aedeagus (Fig. 25) narrower at apex than at base, apex slightly distended, with blunt, weakly developed apicolateral prominences . . . . . . . . . . . . . *blanchardi*

## *Anthonomus signatipennis* Blanchard

Figs. 1, 2, 13, 19, 20, 42

*Anthonomus signatipennis* Blanchard 1851: 387. ***Holotype.*** **Chile**, "provincia de Coquimbo," male, labelled with a green disc and [67/ 7] [TYPE] [MUSEUM PARIS/ CHILI/ CL. GAY 1849] [Anthonomus/ signatipennis/ Type Blanchard/ H. Perrin det. 19] (MNHN). Blackwelder 1947: 839. Schenkling and Marshall 1934: 59. Wibmer and O'Brien 1986: 204.

Recognition (Figs. 1, 2). Adults of *A. signatipennis* are distinguished by the following combination of characters:

> Elytra (Figs. 1, 2) without posterolateral maculae; interstria 2 with posteromedian pallid portion bounded anteriorly and posteriorly with short dark portions; interstriae 3, 5, 7 and 9 with long posteromedian dark portion contrasting with short dark portions on interstriae 4, 6 and 8; aedeagus (Figs. 19, 20) with broad, blunt apicomedian prominence.

They are easily distinguished from adults of the other members of the *A. ornatus* group by the distinct elytral pattern. They lack the large posterolateral elytral maculae characteristic of adults of the other members of the group. Distinctive are the prominent posthumeral patch of pallid scales, the oblique discal fascia of pallid scales extending across interstriae 1–4, and the oblique, alternating dark and pallid elytral fasciae. They are most likely to be confused with adult *A. ornatus* but, in addition to the different elytral pattern (cf. Figs. 1–4), the female sternum 5 lacks posteromarginal emarginations and the male aedeagus lacks acute subapicolateral prominences (cf. Figs. 19, 21, 23).

Adult male. *Length:* 3.28–3.64 mm ($\bar{x}$ = 3.40, n = 10). *Width:* 1.46–1.60 mm ($\bar{x}$ = 1.53, n = 10). *Rostrum:* length 1.30–1.51 × ($\bar{x}$ = 1.40, n = 10) pronotal length; distal portion finely punctate, length 18–30% ($\bar{x}$ = 23, n = 10) of total rostral length. *Prothorax:* pronotum with pallid scales in broad subapical fascia and in posterolateral vittae. *Elytra:* interstriae 3 and 5 slightly elevated at base and on disc; integument and scales dark on humeri, on basal, elevated portions of interstriae 3 and 5, on discal portions of interstriae 1–3, in oblique, irregular, anteromedian and posteromedian fasciae, and on apices of interstriae 4–6; pallid integument and scales predominant in small oblique patches extending across interstriae 1–3, in large, rectangular patch behind humeri, in narrow, oblique, anteromedian fascia that extends posteriorly from interstria 5 to suture, in broader, oblique posteromedian fascia, and on declivity. *Abdomen:* posteromedian portion of sternum 5 slightly depressed behind transverse impression. *Legs:* protibia with slight ventral marginal prominence at proximal ⅓; metatibia narrow, ventral margin slightly, broadly convex in middle ⅔; metatibial mucro short, straight, acute, not excavated.

Adult female. *Length:* 3.40–3.72 mm ($\bar{x}$ = 3.52, n = 10). *Width:* 1.56–1.66 mm ($\bar{x}$ = 1.61, n = 10). *Rostrum:* length 1.25–1.47 × ($\bar{x}$ = 1.36, n = 10) pronotal length; distal portion subcylindrical, shallowly punctate, glabrous, length 22–29% ($\bar{x}$ = 25, n = 10) of total rostral length. *Pygidium* (Fig. 13): apical margin rounded, without subapical ridge. *Abdomen:* sternum 5 without median emargination. *Legs:* metatibial mucro minute.

Distribution (Fig. 42). The 336 adult specimens of *A. signatipennis* examined are from the following localities. ARGENTINA. *Neuquén:* San Martín de los Andes. *Río Negro:* Ñorquincó. *Santa Cruz:* Cañadón León; Lago Argentina. CHILE. *Aisén:* Chile Chico; Coyhaique; 10 km. N Puerto Ibáñez. *Bío-Bío:* Los Barros, Laguna Laja; Volcán Copahue. *Cautín:* Cherquenco. *Chiloé:* Castro; Chepu; Dalcahue. *Concepción:* Salto de Laja. *Llanquihue:* Lepihue, W of Puerto Montt; Puerto Varas; Los Muermos; Maullín; Puerto Montt. *Magallanes:* Estancia Camerón; Estancia Fenton; Laguna Amarga; Puerto Williams; Punta Arenas; Quinta Pittet; Río Santa María. *Malleco:* Lonquimay; Licura; Laguna Malleco; 19 km. E Manzanar; 20 km. E Manzanar; Pichinahuel, Cordillera Nahuelbuta; 38 km. SE Victoria. *Ñuble:* Las Cabras, Cordillera Chillán; Shangrila, 75 km. E Chillán. *Osorno:* Laguna la Copa, Parque Nacional de Puyehue. *Santiago:* Melocotón; 4 km. W Portillo; Quinta San Ramón. *Talca:* 5 km. W Molino. *Valparaíso:* Algarrobo. The specimens examined were collected during the months of October through February and in April.

Plant associations. Adults of *A. signatipennis* were collected on *Berberis buxifolia* at Chepu, Chiloé, Quinta Pittet and Puerto Williams, Magallanes; on *B. chilensis* at Salto de Laja, Concepción and Algarrobo, Valparaíso; on *B. darwinii* at Laguna la Copa, Osorno, and on *B. ilicifolia* at Chile Chico, Aisén, Chile.

### *Anthonomus ornatus* Blanchard

Figs. 3, 4, 14, 17, 21–24, 38–41, 43

*Anthonomus ornatus* Blanchard 1851: 387. ***Holotype.*** **Chile**, female, "provincia de Coquimbo," labelled with green disc and [15/ 43] [illegible handwritten label] [Anthonomus/ ornatus.] [TYPE] [MUSEUM PARIS/ CHILE/ Gay 1843] (MNHN). Kuschel 1950: 17 (= *biplagiatus* Fairmaire, not Redtenbacher [*redtenbacheri* Blackwelder]). Ashworth and Hoganson 1987. Schenkling and Marshall 1934: 58. Wibmer and O'Brien 1986: 204 (= *biplagiatus* Fairmaire, not Redtenbacher [*redtenbacheri* Blackwelder]).

*Anthonomus biplagiatus* Fairmaire 1884: 503–504. ***Holotype.*** **Chile**: "Punta-Arena," female [223] [TYPE] [MUSEUM PARIS/ SANTA-CRUZ/ LEBRUN 1883] [anthonomus/ biplagiatus/ Fairm] (MNHN). Kuschel 1950: 17. Wibmer and O'Brien 1986: 204.

*Anthonomus redtenbacheri* Blackwelder 1947: 839. Replacement name for *A. biplagiatus* Fairmaire (1884) not Redtenbacher (1867).

Recognition (Figs. 3, 4). Adults of *A. ornatus* are distinguished by the following combination of characters:

> Elytra (Figs. 3, 4) with large posterolateral maculae; pallid dorsal annuli around maculae broken dorsomedially by dark posteromedian portion on interstria 2; sutural elytral interstriae without apical extensions; sternum 5 of female (Fig. 17) with deep apicomedian emarginations on each side of slender median projection; aedeagus (Figs. 21–24) symmetrical, with rounded apex and acute lateral prominences; pygidium of female (Fig. 14) with weakly developed subapical prominences.

They are distinguished from adults of *A. signatipennis* by the characters discussed under the latter. The elytral patterns are distinct in all specimens of *A. ornatus* examined but there is considerable variation in the ratio of dark and pallid portions. In some, the pallid portions are extensive and clothed wtih predominantly white scales, with dark fuscous portions correspondingly limited primarily to the elevated basal and discal portions of interstria 3 and to the edges of the posterolateral maculae. In others, the pallid portions are more extensive, the pallid scales are mostly ferruginous, and dark integument and fuscous scales are extensive on the basal portions of interstriae 2–5, on the median portion of the disc, on the posterolateral maculae and on the declivity. The specimen illustrated (Figs. 3, 4) is somewhat intermediate between the extremes. There is also variation in the shape of the aedeagus. At one extreme the sides, seen in dorsal view (Fig. 21), are subparallel behind the apicolateral projections and the lateral plates are only slightly distended dorsally, as seen in lateral view (Fig. 22). At the other extreme, the sides are broadly constricted in the distal ⅔ in dorsal view (Fig. 23) and the lateral plates are correspondingly distended dorsally in lateral view (Fig. 24). This variation is not geographical; both extremes are exhibited in specimens from Trapatrapa, Concepción, which do not differ otherwise.

Adult male. *Length:* 2.56–3.32 mm ($\bar{x}$ = 2.90, n = 10). *Width:* 1.16–1.60 mm ($\bar{x}$ = 1.39, n = 10). *Rostrum:* length 1.40–1.70 × ($\bar{x}$ = 1.60, n = 10) pronotal length; distal portion finely punctate, length 23–32% ($\bar{x}$ = 28, n = 10) of total rostral length. *Prothorax:* pronotum without distinct subapical fascia and dorsolateral vittae of pallid scales. *Elytra:* interstria 3 with slightly elevated basal and discal portions; dark integument and scales predominant on humeri, on basal elevated portions of interstriae 3 and 5 and on discal portions of interstriae 1–3, forming irregular edges of posterolateral maculae, and on apices of interstriae 4–6; pallid integument and scales predominant on posthumeral portions, in broad annuli around edges of posterolateral maculae, in median portion of that macula, and on declivity. *Abdomen:* posteromedian portion of sternum 5 slightly depressed behind transverse impression. *Legs:* protibia with slight midventral marginal prominence; metatibia narrow, straight, with slight ventral marginal prominence; metatibial mucro large, curved, excavated.

Adult female. *Length:* 2.48–3.32 mm ($\bar{x}$ = 2.98, n = 10). *Width:* 1.12–1.58 mm ($\bar{x}$ = 1.41, n = 10). *Rostrum:* length 1.59–1.76 × ($\bar{x}$ = 1.68, n = 10) pronotal length; distal portion slender, shining, glabrous, length 29–37% ($\bar{x}$ = 35, n = 10) of total rostral length. *Legs:* metatibial mucro minute.

Larva (2 specimens from Frutillar, Llanquihue, Chile, collected November 2, 1983, by G. Kuschel, *ex* flower buds *Berberis buxifolia*). The third instar larva of *A. ornatus* resembles that of *A. kuscheli* in size and other characters except as follows: it is more strongly curved; the ninth abdominal segment is not as long; and there are four epipharyngeal sensory pores instead of three as in *A. kuscheli.* The significance of these apparent differences will have to await the availability of additional specimens.

Pupa (5 specimens from Frutillar, Llanquihue, Chile, collected November 2, 1983, by G. Kuschel *ex* flower buds of *Berberis buxifolia*). *Body:* length 3.8–4.2 mm (n = 5). *Head* (Fig. 38): frontal setae straight to slightly curved; each borne on summit of small, rounded tubercle; pair separated by distance greater than length of a seta. Supraorbital setae absent. One pair of fine basirostral (interocular) setae; each about ½ length of frontal seta. One pair of minute sessile distirostral setae. *Pronotum* (Fig. 39): pronotal setae straight to feebly curved; setae on anterior margin slightly longer and stouter than posterior setae. Anteromedian setae each borne subapically on anterior face of conical, sharply pointed tubercle; tubercles separated by distance equal to ca. width of tubercle at base. Three pairs of anterolateral setae; each borne on summit of slight to distinct tubercle; tubercle of anterolateral 3 often taller than others; setae on each side of pronotum in straight to feebly curved line. Posteromedian setae each borne at or near apex of subconical to acutely pointed tubercle; tubercles separated by distance slightly greater than length of a seta. Three pairs of posterolateral setae; arranged in curved line on each side of pronotum; each borne on summit of small, rounded tubercle. *Mesonotum:* three pairs of straight mesonotal setae; each borne on summit of rounded tubercle or seta, innermost occasionally subapical on small, acutely pointed tubercle. *Metanotum:* three pairs of straight to curved metanotal setae; more widely spaced than mesonotals; each borne on summit of rounded tubercle; metanotal 2 usually located closer to 3 than to 1. *Abdomen* (Fig. 40): three pairs of discotergal setae and occasionally with additional setaless tubercles on some terminal segments; setae each borne on summit of low tubercle on first two abdominal terga, remaining terga with seta located at base of sharply pointed tubercles that become progressively larger posteriorly. Laterotergal setae 1 and 2 present on each of first 8 terga; seta 1 minute, borne at base of small, sharply pointed tubercle on all terga; seta 2 borne subapically on sharply pointed tubercle, slightly curved, longer than discotergal setae. Anteronotal setae absent. Spiracles well developed on first 5 abdominal segments, feebly developed on segment 6, absent on others. Laterosternal and sub-laterosternal setae absent. Segment 9 bearing a single sharply pointed process which in side view (Fig. 41) is turned slightly upward apically; minute seta borne on each side of segment ca. midway between apex and base of segment.

Distribution (Fig. 43). The 235 adult specimens of *A. ornatus* examined are from the following localities: ARGENTINA. *Neuquén:* San Martín de los Andes. *Río Negro:* Colonia Catedral; Ñorquincó; Río Foyel. *Santa Cruz:* Cañadón León. *Tierra del Fuego:* Bahía San Sebastián, Punta de Arenas. CHILE. *Aisén:* Chile Chico; Coyhaique; Lago Escondido; Lago Frío; 10 km. N Puerto Ibáñez; Quellón. *Bío-Bío:* Los Barros, Laguna Laja. *Chiloé:* Chepu. *Concepción:* Trapatrapa. *Linares:* Parral. *Llanquihue:* Frutillar; Río Peñón, Maullín. *Magallanes:* Cerro Castillo; Dos Lagunas; Estancia Camerón; Estancia Canelo; Estancia Fenton; Isla Navarino; Laguna Azul and Ultima Esperanza, Parque Nacionál Torres del Paine; Laguna Los Robles; Quinta Pittet; Puerto Williams; Punta Arenas; Rusfin; Río Tres Pasos; Río el Ganso, Seno de Otway. *Malleco:* Icalma; La Fusta; 20 km. E Manzanar; Marimenuco; Cordillera Nahuelbuta; Villa Portales. *Ñuble:* Cordillera Chillán, Las Cabras, Las Trancas, 70 km. E Chillán; El Marchant; Recinto; 4.5 km. SE Recinto. *Osorno:* Antillanca; 2 km. SW Vn. Casablanca, Parque Nacional de Puyehue. The specimens examined were collected during the months of October through February and in April and August. Only one of the specimens on which the reference to *A. ornatus* by Ashworth and Hoganson (1987: 887) is based is that species. The others are *A. signatipennis, A. berberidis* and *A. kuscheli.*

Plant associations. Specimens of *A. ornatus* were collected on *Berberis buxifolia* at Chepu, Chiloé, Frutillar, Llanquihue, and Quinta Pittet and Puerto Williams, Magallanes; on *Berberis ilicifolia* at Chile Chico, Aisén, and Puerto Williams, Magallanes; and on *Berberis* sp. at Trapatrapa, Concepción, and Laguna Azul and Ultima Esperanza, Magallanes, Chile.

### ***Anthonomus blanchardi* Clark, NEW SPECIES**

Figs. 18, 25, 26, 45

Type specimens. ***Holotype:*** **Chile**, male [CHILE/ El Coigo/ Cord. Curico/ Oct–Nov 1959] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand] (NZAC). *Paratypes:* Chile, 1 male, 2 females [CHILE/ El Coigo/ Cord. Curico/ Nov–Dec 1959] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 female [Santiago/ Farellones/ 2200 m/ 10 Dec 1950] [G. Kuschel/ Berberis/ buxifolia] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 female [Chile:

8600'/ Farellones/ P. Santiago/ XII-25-1968] [under dung L &/ C. W. O'Brien]; 1 female [Chile Santiago/ Peñalolén/ 25-I-1975/ Coll: M. Beeche]; 1 female [Altos de Vilches/ Talca A280 mts./ 25–26-XI-1970/ J. Solvericens]. Total paratypes, 7 (CWOB, MNNC, NZAC).

Recognition. Adults of *A. blanchardi* are distinguished by the following combination of characters:

> Elytra (cf. Figs. 3, 4) with large posterolateral maculae; pallid dorsal annuli around macula broken medially by dark posteromedian portion on interstria 2; sutural elytral interstriae without apical extensions; sternum 5 of female (Fig. 18) with shallow apicomedian emarginations on each side of short median prominence; aedeagus (Fig. 25, 26) symmetrical, narrowed in distal ½, with rounded apex and short, acute apicolateral prominences; pygidium of female (cf. Fig. 14) with weakly developed subapical prominences.

They are distinguished from adults of the closely allied *A. ornatus* by characters of the male genitalia and of sternum 5 of the female. The aedeagus of *A. blanchardi* (Figs. 25, 26) is constricted and narrowed in the distal ⅔ to the apex. The apex itself is slightly distended, rather than being rounded as in *A. ornatus* (cf. Figs. 21, 23, 25). It is also narrower than the apex in that species and has less well-developed apicolateral prominences. The median posteromarginal prominence on sternum 5 of the female is bounded on each side by shallow emarginations rather than being deeply incised as in *A. ornatus* (cf. Figs. 17, 18).

Adult male. *Length:* 2.48–2.68 mm ($\bar{x}$ = 2.58, n = 2). *Width:* 1.30–1.34 mm ($\bar{x}$ = 1.32, n = 2). *Rostrum:* length 1.43–1.55 × ($\bar{x}$ = 1.49, n = 2) pronotal length; distal portion finely punctate, length 32–35% ($\bar{x}$ = 34, n = 2) of total rostral length. *Prothorax:* pronotum without distinct subapical fascia and dorsolateral vittae of pallid scales. *Elytra:* interstria 3 with slightly elevated basal and discal portions; dark integument and scales predominant on humeri, on basal elevated portions of interstriae 3 and 5 and on discal portions of interstriae 1–3, forming irregular edges of posterolateral maculae, and on apices of interstriae 4–6; pallid integument and scales predominant on posthumeral portions, in broad annuli around edges of posterolateral maculae, in median portion of macula, and on declivity. *Abdomen:* posteromedian portion of sternum 5 slightly depressed behind transverse impression. *Legs:* protibia with slight midventral marginal prominence; metatibia narrow, straight, with slight ventral marginal prominence; metatibial mucro large, curved, excavated.

Adult female. *Length:* 2.48–3.16 mm ($\bar{x}$ = 2.81, n = 6). *Width:* 1.10–1.50 mm ($\bar{x}$ = 1.34, n = 6). *Rostrum:* length 1.54–1.69 × ($\bar{x}$ = 1.62, n = 6) pronotal length; distal portion slender, shining, glabrous, length 30–40% ($\bar{x}$ = 35, n = 6) of total rostral length. *Legs:* metatibial mucro minute.

Distribution (Fig. 45). *Anthonomus blanchardi* is known from the type series from the following localities. CHILE. *Curicó:* El Coigo, Cordillera Curicó. *Santiago:* Farellones; Peñalolén. *Talca:* Altos de Vilches.

Plant associations. The paratype of *A. blanchardi* from Farellones, Santiago, Chile, was collected on *Berberis buxifolia.*

Etymology. This species is named for Charles Emile Blanchard (1819–1900) in honor of his contribution to the study of the *A. ornatus* group.

## ***Anthonomus kuscheli* Clark, NEW SPECIES**

Figs. 5, 6, 15, 27, 31–37, 44

Type specimens. ***Holotype:* Chile**, male [CHILE/ Pichinahuel/ Cord. Nahuelbuta/ 1–31 Jan 1959] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand] (NZAC). *Paratypes:* Argentina, 1 female [Argentina/ Rio Negro/ L. Nahuelhuapí/ Llao Llao] [24 Nov 1950/ W. Wittmer] [Coll. Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male [Argentina/ R. Negro/ L. Nahuelhuapí] [1 Mar 1949/ W. Wittmer] [Coll. Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]. Chile, 1 male [CHILE] [Entomology/ Division/ D.S.I.R./ New Zealand]; 3 males [Aysen/ Río Correntoso/ 22-I-1971/ F. Silva G.] [Ex. Berberis/ buxifolia]; 1 male, 2 females [CHILE: P./ Aisen, 7 km./ W. Coyhaique/ I-21-1968] [at night L. &/ C. W. O'Brien]; 1 female [CHILE: P./ Aisen, 15 km./ W. Coyhaique/ I-21-1968] [Collectors: L &/ C. W. O'Brien]; 1 male [Bío-Bío/ Pemehue/ R. Renaico] [12 Jan 1946/ G. Kuschel] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male [male symbol] [Cautín/ Vn. Llaima/ 17 Sep 1951/ M. Codoceo] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male, 1 female [CHILE/ Chiloé/ Chepu/ 22.10.58] [s/ Berberis/ darwini] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male, 1 female [CHILE/ Chiloé/ Chepu/ 23.9.54] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 6 males, 7 females [CHILE, Llanquihue/ Frutillar/ 31 October 1983/ G. Kuschel] [Berberis/ darwini/ em. 9 Nov 1983]; 1 female [CHILE/ Frutillar/ 27 Feb 1950/ G. Kuschel] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male [CHILE/ Pichinahuel/ Cord. Nahuelbuta/ 1–31 Jan 1959] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 2 males [CHILI/ Pichinahuel 1200 m/ 14–18 Feb 1956] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 12 males, 17 females [CHILE: 19 km./ E. Manzanar/ P. Malleco/ XI-3-1967] [Collectors: L &/ C. W. O'Brien]; 1 female [Chile: 20 km./ SE Victoria/ P. Malleco/ XI-3-1967] [Collectors: L &/ C. W. O'Brien] [compared/ with type] [Anthonomus/ ornatus/ Blanch/ det COB 1971]; 2 males, 2 females [Chile: 20 km./ SE. Victoria/ P. Malleco/ XI-3-1967] [Collectors: L &/ C. W. O'Brien]; 1 male, 1 female [Chile: 38 km./ SE. Victoria/ P. Malleco/ XI-3-1967] [Collectors: L &/ C. W. O'Brien]; 1 female [CHILE: Laguna de Copa/ P. N. de Puyehue, Osorno Pro./ Site 20, El. 520 m. 7-XII-77/ Valdivian Rain Forest/ Ashworth, Hoganson, Mooers] [on Berberis darwinii] [Anthonomus/ ornatus/ Blanchard]; 14 males, 8 females [CHILE: Laguna Espejo/ P. N. de Puyehue, Osorno Pro./ Site 17, El. 520 m. 21-XII-77/ Valdivian Rain Forest/ Ashworth, Hoganson, Mooers] [on Berberis darwinii] [Anthonomus/ ornatus/ Blanchard]; 1 male, 2 females [CHILI/ Panquipulli/ Valdivia/ 12 Jan 1944] [G. Kuschel/ Collection] [Entomology/ Division / D.S.I.R./ New Zealand]. Total paratypes, 95; (CACA, CWOB, MNNC, NZAC, TAMU).

Recognition (Figs. 5, 6). Adults of *A. kuscheli* are distinguished by the following combination of characters:

> Elytra (Figs. 5, 6) with posterolateral maculae; pallid dorsal annuli around maculae uninterrupted by dark portion on interstria 2; sutural elytral interstriae without apical extensions; aedeagus (Fig. 27) symmetrical, narrowed apically, with slight subapicolateral prominences; pygidium of female (Fig. 15) with subapical prominences; sternum 5 of female with small apicomedian prominence; endophallus (Fig. 27) with two dentate median sclerites in addition to distal sclerite.

They resemble *A. ornatus* but are more elongate in body form and have the discal area of the elytra more flattened so that the basal and discal elevations of interstria 3 are not so distinct. In addition, the pallid annuli around the dorsal portions of the posterolateral elytral maculae are complete in *A. kuscheli* (Figs. 5, 6), not interrupted by a dark portion of interstria 2 as in *A. ornatus* (Figs. 3, 4). The anterior margin of the macula is also less irregular in *A. kuscheli*. Additional differences are found in the male genitalia and in the female abdomen and pygidium. The aedeagus of *A. kuscheli* is strongly narrowed toward the apex and the apicolateral prominences are weakly developed (Fig. 27). The deep posteromedian incisions of sternum 5 of the female *A. ornatus* are replaced in *A. kuscheli* by a small apicomedian prominence. The female pygidium has large subapical prominences in *A kuscheli* (Fig. 15), whereas the prominences are weakly developed in *A. ornatus* (Fig. 14).

Adult male. *Length:* 2.72–3.00 mm ($\bar{x}$ = 2.86, n = 10). *Width:* 1.22–1.32 mm ($\bar{x}$ = 1.26, n = 10). *Rostrum:* length 1.31–1.59 × ($\bar{x}$ = 1.46, n = 10) pronotal length; length of distal portion 24–33% ($\bar{x}$ = 28, n = 10) of total rostral length. *Prothorax:* pronotum without distinct subapical fascia and dorsolateral vittae of pallid scales. *Elytra:* interstria 3 with slightly elevated basal portion, discal elevation feebly developed; dark integument and scales predominant on basal and discal elevations of interstria 3 and around edges of large, posteromedian maculae; pallid integument and scales predominant on sides behind humeri and in complete annuli around dorsal portions of posterolateral maculae. *Abdomen:* posteromedian portion of sternum 5 slightly depressed behind transverse impression. *Legs:* protibia with slight ventral marginal prominence at proximal ⅓; metatibia narrow, straight, with slight ventral marginal prominence at proximal ¼; metatibial mucro large, curved, excavated.

Adult female. *Length:* 2.60–3.12 mm ($\bar{x}$ = 2.88, n = 10). *Width:* 1.12–1.40 mm ($\bar{x}$ = 1.26, n = 10). *Rostrum:* length 1.38–1.61 × ($\bar{x}$ = 1.49, n = 10) pronotal length; distal portion subcylindrical, shallowly punctate, glabrous, length 29–38% ($\bar{x}$ = 33, n = 10) total rostral length. *Abdomen:* sternum 5 with small apicomedian prominence. *Legs:* metatibial mucro short, curved.

Larva (8 specimens from Frutillar, Llanquihue, Chile, collected October 31, 1983, by G. Kuschel, *ex* flower buds of *Berberis darwini*). *Body* (Fig. 31): curved; length 3.1–5.4 mm (n = 8). Asperities rounded to subconical, fairly evenly distributed over body. Color dingy white, except for brownish pigmented pronotal area. *Head* (Fig. 32): dark brown; width of head capsule 0.51–0.54 mm (n = 8). Basal article of antenna bearing elongate-oval accessory appendage and three short, stout setae, one of which is longer than others. Endocarina (endocarinal line) distinct, slightly longer than ½ length of frons. Epicranial suture (coronal suture) less than ½ length of head capsule. Four pairs of frontal setae; setae 1 and 3 short, seta 4 ca. 2× length of 3, seta 5 distinctly longer than 4; seta 3 located dorsolaterad of 4. Two pairs of frontal sensilla, one pair in front of frontal setae 1 and other pair located dorsolaterad of setae 3. Five pairs of dorsal epicranial setae; setae 1, 4 and 5 slender, long, ca. equal in length; setae 2 and 3 nearly equal in length, distinctly shorter than other dorsal epicranial setae; seta 3 remote from frontal suture; seta 4 closer to frontal suture than seta 1. Four pairs of minute, peglike posterior epicranial setae that tend to be arranged in a slightly curved line; the lower seta of series located directly above or slightly mesad of dorsal epicranial seta 2. Three pairs of posterior epicranial sensilla; one pair near vertex; one pair dorsad and mesad of dorsal epicranial seta 1; one pair about halfway between dorsal epicranial setae 4 and 5. Lateral epicranial seta 1 short, about ⅓ length of seta 2. Ventral epicranial setae 1 and 2 ca. equal in length. Clypeus (Fig. 35) with an oblique narrow, nonpigmented area on each side. Clypeal setae slender; seta 1 slightly longer and sometimes located closer to anterior margin of frons than 2. One pair of clypeal sensilla that are located closer to seta 1 than to 2. Three pairs of labral setae; setae 1 and 2 ca. same length; seta 3 shorter. Epipharynx (Fig. 34) (epipharyngeal lining) bearing two pairs of anteromedian setae of ca. same length. Three pairs of stout anterolateral setae present. Labral rods (tormae) stout, converging posteriorly. Three epipharyngeal sensory pores arranged in single cluster. Two pairs of stout median epipharyngeal spines present between labral rods (tormae). Mandible (Fig. 37) with two well-defined teeth; occasionally outermost tooth considerably reduced; two slender setae ca. same length; one sensillum. Maxillary palps (Fig. 33) with apical article slightly longer than basal article, bearing several minute papillae at apex and sensillum; basal article with short seta and two sensilla. Stipial setae 1, 3 and 4 long, seta 1 slightly longer than other two; seta 2 much shorter than others. Mala (lacinial lobe) bearing 11 stout setae, 6 ventral (ventral lacinial) and 5 dorsal (dorsal lacinial). Labial palpus consists of one segment that bears several small papillae at apex and sensillum. Premental sclerite with long posterior process. One pair of long premental (prelabial) setae present. Three pairs of glossal setae of ca. equal size. Postmental setae (postlabial) 1 and 3 each shorter than 2. *Thorax* (Fig. 31) (setae described on one side of body only): pronotum bearing 8 long setae and two short ones. Five postdorsal setae present; setae 2 and 5 shorter than others. Two spiracular (alar) setae present; one several times longer than other. Epipleural (dorsopleural) lobe bearing one long seta. Two long pleural (ventropleural) setae on prothorax; one seta on each of meso- and metathorax. Three long pedal (laterosternal) setae. Sternal (mediosternal) seta minute. *Abdomen* (Fig. 31): posterior margins of most or all of first seven abdominal segments emarginate dorsally (Fig. 36). Abdominal segments 1–7 bearing three distinct dorsal folds. Prodorsum (fold I) of segments 1–8 with short setae. Five postdorsal (setae of abdominal segment, fold III) setae present; setae 1, 3 and 5 longer than 2 and 4. Two spiracular (alar) setae; seta 2 ca. 3× longer than 1. Epipleurum (dorsopleurum) bearing one long and one short seta. One short pleural (ventropleural) seta and pedal setae ca. same length. Two minute pedal setae present. Anus subterminal; surrounded by four lobes, each bearing minute seta. Seven pairs of minute setae borne on segment 9. Spiracles bicameral; air tubes with 6 annuli.

Pupa (5 specimens from Frutillar, Llanquihue, collected October 31, 1983, by G. Kuschel, *ex* flower buds of *Berberis darwini*). The pupa of *A. kuscheli* is similar in form and size to *A. ornatus* except the posteromedian pronotal tubercles tend to be larger and the setae are borne apically rather than subapically as usual with the latter species. The best distinguishing character appears to be the discotergal setae on terga 6, 7 and 8 that are borne on the summits of rounded tubercles rather than subapically on acutely pointed tubercles as in *A. ornatus.*

Distribution (Fig. 44). The type series of *A. kuscheli* consists of adult specimens from the following localities. ARGENTINA. *Río Negro:* Llao Llao, Lago Nahuel Huapí. CHILE. *Aisén:* 7 km. W Coyhaique, Río Correntoso. *Bío-Bío:* Pemehue. *Cautín:* Volcán Llaima. *Chiloé:* Chepu. *Llanquihue:* Frutillar. *Malleco:* 19 km. E Manzanar, Cordillera Nahuelbuta, Pichinahuel, 20 and 38 km. SE Victoria. *Valdivia:* Panquipulli.

Plant associations. Specimens of *A. kuscheli* were collected on *Berberis darwini* at Chepu, Chiloé, and Frutillar, Llanquihue; and on *B. buxifolia* at Río Correntoso, Aisén, Chile. Larvae and pupae were taken from flower buds of *B. darwini.*

Etymology. This species is named in honor of Guillermo Kuschel to commemorate his contributions to the understanding of the weevil fauna of Chile and as a token of appreciation for help extended in the preparation of this paper.

### *Anthonomus araucanus* Clark, New Species

Figs. 7, 8, 16, 28, 45

Type specimens. ***Holotype:*** **Chile**, male [CHILE/ Laguna Laja/ Los Barros 1500 m/ 14 Jan 1948] [on/ Berberis] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand] (NZAC). *Paratypes:* Chile, 2 females [CHILE/ Laguna Laja/ Los Barros

1500 m/ 14 Jan 1948] [on/ Berberis] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 2 males [Bío-Bío/ Cord. Pemehue/ 1500 m] [16 Jan 1944/ G. Kuschel] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 female [Bío-Bío/ La. Laja/ Los Barros/ 1500 m] [13 Jan 1945/ G. Kuschel] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male, 4 females [Chile: 19 km/ E. Manzanar/ P. Malleco/ XI-3-1967] [Collectors L &/ C. W. O'Brien]; 2 males [CHILE, Malleco Prov./ 20 km E Manzanar/ 1100 m 19–21.xii./ 1976 H. F. Howden] [beating]; 4 males [Malleco/ L. Malleco/ 1100 m] [22 Jan 1946/ G. Kuschel] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 female [Chile. 12 km./ W. Curicautin (sic)/ P. Malleco/ XI-3-1967] [Collectors L &/ C. W. O'Brien]; 3 males, 3 females [Chile: 20 km./ SE. Victoria/ P. Malleco/ XI-3-1967]. Total paratypes, 23; (CWOB, HAHC, NZAC, TAMU).

Recognition. Adults of *A. araucanus* are distinguished by the following combination of characters:

> Elytra (Figs. 7, 8) with prominent midbasal macula; sutural elytral interstriae without apical extensions; posterolateral elytral maculae weakly developed (Figs. 7, 8), pallid annuli around maculae broken by dark portion on posteromedian portion of interstria 2; rostrum of female short, relatively stout; pygidium of female (Fig. 16) with small apicomedian prominence; aedeagus (Fig. 28) symmetrical, narrowed to bluntly rounded apex; endophallus (Fig. 28) with two dentate median sclerites in addition to distal sclerite.

They are similar in appearance to adults of *A. berberidis*. They are relatively small. In addition, the elytral patterns, with the exception of the prominent, dark midbasal macula, are feebly developed in both species (cf. Figs. 7, 8, 11, 12). The two are easily distinguished; *A. araucanus* lacks the apical extensions of the sutural elytral interstriae and the large prominence on sternum 5 of the male. In addition, adults of *A. araucanus* have the aedeagus symmetrical rather than asymmetrical as in adult *A. berberidis* (cf. Figs. 28, 30).

Adult male. *Length:* 1.88–2.52 mm ($\bar{x}$ = 2.36, n = 10). *Width:* 0.84–1.22 mm ($\bar{x}$ = 1.12, n = 10). *Rostrum:* length 1.33–1.64 × ($\bar{x}$ = 1.44, n = 10) pronotal length; length of distal portion 23–32% ($\bar{x}$ = 27, n = 10) of total rostral length. *Prothorax:* pronotum without subapical fascia and dorsolateral vittae of pallid scales, middorsal vitta indistinct. *Elytra:* interstria 3 with slight basal and discal elevations; dark integument and scales predominant in large, midbasal macula and forming edges of weakly developed posterolateral maculae. *Abdomen:* sternum 5 with slight apicomedian prominence. *Legs:* protibia with slight ventral marginal prominence at proximal ⅓; metatibia narrow, ventral margin slightly curved in distal ⅔, with slight prominence at proximal ¼; metatibial mucro large, curved, excavated.

Adult female. *Length:* 2.00–2.44 mm ($\bar{x}$ = 2.30, n = 10). *Width:* 1.02–1.22 mm ($\bar{x}$ = 1.08, n = 10). *Rostrum:* length 1.00–1.52 × ($\bar{x}$ = 1.37, n = 10) pronotal length; distal portion subcylindrical, shallowly punctate, glabrous, length 25–34% ($\bar{x}$ = 30, n = 10) total rostral length. *Abdomen:* sternum 5 with posterior margin straight. *Legs:* metatibia straight, narrow at apex; metatibial mucro short, straight.

Distribution (Fig. 45). The type series of *A. araucanus* consists of adult specimens from the following localities. CHILE. *Bío-Bío:* Laguna Laja, Cordillera Pemehue. *Malleco:* 12 km. W Curacautín; 20 km. E Manzanar; Laguna Malleco; 20 km. SE Victoria.

Plant associations. The holotype and two paratypes were collected on *Berberis* sp. at Los Barros and Laguna Laja, Bío-Bío, Chile.

Etymology. The name of this weevil is derived from that of the Araucanians and emphasizes the fact that it occurs in the heart of their country and that of the *Araucaria*.

### ***Anthonomus chilicola*** **Clark,**
### New Species

Figs. 9, 10, 29, 44

Type specimens. ***Holotype:*** **Chile**, male [CHILE, Malleco Prov./ 20 km E Manzanar/ 1100 m 19–21.xii./ 1976 H. F. Howden] [beating] (HAHC). *Paratypes:* Chile, 3 males [CHILE, Malleco Prov./ 20 km E Manzanar/ 1100 m 19–21.xii./ 1976 H. F. Howden] [beating] (HAHC).

Recognition (Figs. 9, 10). Adults of *A. chilicola* are distinguished by the following combination of characters:

> Sutural elytral interstriae with acute, overlapping apical extensions; with posterolateral elytral maculae (Figs. 9, 10); pallid annuli around dorsal portions of maculae extending across part of short posteromedian dark portion on interstria 2; metatibia of male with ventral margin strongly concave in distal ⅔, apical mucro enlarged, excavated; aedeagus (Fig. 29) asymmetrical, constricted medially, with slight subapicolateral prominences.

Like adults of *A. kuscheli,* adult *A. chilicola* are more slender than those of *A. ornatus* (cf. Figs. 4, 10). The elytral pattern in *A. chilicola* is essentially the same as in *A. ornatus,* but the pallid annuli around the posterolateral maculae are partially interrupted by enroachment of dark integument and scales on interstria 2 (Fig. 10). Adult *A. chilicola* are further distinguished from adults of both of these species, however, by the apical extensions of the sutural elytral interstriae, by the male metatibia which is strongly, broadly concave on the ventral margin and has a much larger, more strongly excavated metatibial mucro, and by the asymmetrical aedeagus. These are all characters adult *A. chilicola* share with adult *A. berberidis,* which are distinguished by the less distinct elytral pattern (cf. Figs. 9–12), the large posterolateral prominence on sternum 5 of the male, and by differences in the aedeagus (cf. Figs. 29, 30).

Adult male. *Length:* 3.40–4.00 mm ($\bar{x}$ = 3.75, n = 4). *Width:* 1.40–1.64 mm ($\bar{x}$ = 1.57, n = 4). *Rostrum:* length 1.47–1.67 × ($\bar{x}$ = 1.58, n = 4) pronotal length; length of distal portion 21–31% ($\bar{x}$ = 25, n = 4) of total rostral length. *Prothorax:* pronotum without distinct subapical fascia and dorsolateral vittae of pallid scales. *Elytra:* interstria 3 with slightly elevated basal and discal portions; dark integument and scales predominant on humeri and on basal and discal elevations of interstria 3, less dense on basal portions of interstriae 2, 4 and 5 and on discal portion of 2, forming broad, irregular edges of posteromedian maculae; pallid integument and scales predominant behind humeri and in oblique fascia extending posteriorly to posteromedian portion of interstria 2 then curving posteriorly to apices of interstriae 4–6. *Abdomen:* posteromedian portion of sternum 5 slightly depressed. *Legs:* procoxae with dense, broad, pallid scales; protibia with slight ventral marginal prominence at proximal ⅓; metatibia narrow, slightly curved, with slight ventral marginal prominence at proximal ¼; metatibial mucro large, curved, excavated.

Adult female. Unknown.

Distribution (Fig. 44). The type series of *A. chilicola* consists of adult specimens from the following locality. CHILE. *Malleco:* 20 km. E Manzanar.

Plant associations. Unknown.

Etymology. The name of this species is derived from that of its native country, emphasizing the unique austral distribution of the group to which it belongs.

### ***Anthonomus berberidis*** **Clark,**
### New Species

Figs. 11, 12, 30, 45

Type specimens. ***Holotype:*** **Chile**, male [CHILE/ Frutillar/ 14 Dec 1943/ G. Kuschel] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand] (NZAC). *Paratypes:* ARGENTINA, 1 male, 1 female [ARGENTINA/ El Bolson, Rio/

Negro/ IX-20-1963/ A. Kovacs]. Chile, 1 male [Chili] [Deyr.]; 2 males, 4 females [CHILE: 19 km. S. of Ancud,/ Is. Chiloe/ Site C2. El. 120 m. 14-II-79/ Valdivian Rain Forest/ Ashworth, Hoganson, Gordon] [on Berberis darwinii] [Anthonomus/ ornatus/ Blanchard]; 5 males, 6 females [CHILE/ Chiloé/ Chepu/ 22.10.58] [s/ Berberis/ darwini] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 3 males, 2 females [Chile: 9 km./ E. Chepu/ Chiloe Is/ II-4-1968] [at night L. &/ C. W. O'Brien]; 2 females [Chile: 13/ km. S. Castro/ Is Chiloe/ II-5-1968] [Collectors: L &/ C. W. O'Brien]; 1 female [Dalcahue/ Chiloe, CHILE]; 1 female [CHILE/ Dalcahue/ Chiloe/ 10–20 Nov 1957] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male [Quellón-Chi/ loe I-1955/ J. S. Vargas]; 1 female [CHILE: Chiloé/ Dalcahue/ 17–31.i.1962/ Luis Peña] [H. & A. Howden/ Collection]; 1 male, 1 female [Pto Montt/ 15.1.71]; 1 female [Chile: 12 km. N./ Puerto Montt/ P. Llanquihue/ II-8-1968] [at night L. &/ C. W. O'Brien]; 3 males, 5 females [CHILE/ Llanquihue/ Frutillar/ 13.9.54] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male, 3 females [CHILE, 2 km./ S. Frutillar/ P. Llanquihue/ 280′ II-3-1968] [Collectors: L &/ C. W. O'Brien]; 1 male, 1 female [CHILE/ Llanquihue/ Frutillar/ 23.9.54] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 3 males, 2 females [CHILE/ Llanquihue/ Frutillar/ 24.2.50] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male, 3 females [CHILE/ Frutillar/ 14 Dec 1943/ G. Kuschel] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male [CHILE/ Frutillar/ 28 Dec 1944/ G. Kuschel] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 1 male, 7 females [CHILE/ Frutillar/ 27 Feb 1950/ G. Kuschel] [G. Kuschel/ Collection] [Entomology/ Division/ D.S.I.R./ New Zealand]; 2 males, 1 female [MAULLIN a/ Las Quemas/ Llanquihue/ 17,-Dic.1972/ Coll: L. E. Pena]; 1 male [CHILE/ Volcán Osorno/ 4.3.50/ Kuschel leg.] [Coll./ Kuschel] [Entomology/ Division/ D.S.I.R./ New Zealand]. 1 male [CHILE: Laguna de Copa/ P. N. de Puyehue, Osorno Pro./ Site 20, El. 520 m. 7-XII-77/ Valdivian Rain Forest/ Ashworth, Hoganson, Mooers] [on Berberis darwinii] [Anthonomus/ ornatus/ Blanchard]; 3 males, 2 females [CHILE: Laguna Espejo/ P. N. de Puyehue, Osorno Pro./ Site 17, El. 520 m. 21-XII-77/ Valdivian Rain Forest/ Ashworth, Hoganson, Mooers] [on Berberis darwinii] [Anthonomus/ ornatus/ Blanchard]; 3 males, 8 females [CHILE: Laguna Espejo/ P. N. de Puyehue, Osorno Pro./ Site 17A. El. 520 m. 10-I-79/ Valdivian Rain Forest/ A. C. Ashworth, J. W. Hoganson] [on Berberis sp.] [Anthonomus/ ornatus/ Blanchard]; Total paratypes, 87; (AMNH, CACA, HAHC, MNNC, MCZC, NZAC, TAMU).

Recognition (Figs. 11, 12). Adults of *A. berberidis* are distinguished by the following combination of characters:

> Sutural elytral interstriae with acute, overlapping apical extensions; posterolateral elytral maculae feebly developed (Figs. 11, 12), surrounded dorsally by complete pallid annuli; sternum 5 of male with large posteromedian prominence; metatibia of male with ventral margin strongly concave in distal ⅔, with enlarged, excavated, apical mucro; pygidium of female with small apicomedian prominence; aedeagus (Fig. 30) asymmetrical, constricted medially, with blunt subapicolateral prominences.

These, and adults of the closely related *A. chilicola* have the aedeagus similarly asymmetrical (cf. Figs. 29, 30), similarly modified male metatibiae with the ventral marginal concavity, enlarged, strongly excavated apical mucrones, and similar extension of the extreme apices of the sutural elytral interstriae. This latter feature is even more pronounced in adult *A. berberidis* where the extension of the right elytron overlaps that of the left one. The elytral pattern of light and dark integument and scales is also similar in adult *A. chilicola* and *A. berberidis,* but is weakly developed in adult *A. berberidis,* which have a prominent midbasal macula (cf. Figs. 9, 12). The large apicomedian prominence on sternum 5 of the male is unique to adults of *A. berberidis.*

Adult male. *Length:* 2.52–3.04 mm ($\bar{x}$ = 2.83, n = 10). *Width:* 1.12–1.44 mm ($\bar{x}$ = 1.28, n = 10). *Rostrum:* length 1.02–1.48 × ($\bar{x}$ = 1.32, n = 10) pronotal length; length of distal portion 22–31% ($\bar{x}$ = 25, n = 10) of total rostral length. *Prothorax:* pronotum without subapical fascia and dorsolateral vittae of pallid scales; middorsal vitta indistinct. *Elytra:* interstria 3 without distinct basal and discal elevations; dark integument and scales predominant in large, midbasal macula and forming edges of weakly developed posterolateral maculae. *Legs:* protibia with distinct ventral marginal prominence at proximal ⅓; metatibia narrow, ventral margin strongly curved in distal ⅔, with distinct prominence at proximal ¼; metatibial mucro large, curved, excavated.

Adult female. *Length:* 2.16–3.16 mm ($\bar{x}$ = 2.87, n = 10). *Width:* 0.92–1.36 mm ($\bar{x}$ = 1.26, n = 10). *Rostrum:* length 0.87–1.40 × ($\bar{x}$ = 1.28, n = 10) pronotal length; distal portion subcylindrical, shallowly punctate, glabrous, length 26–33% ($\bar{x}$ = 29, n = 10) total rostral length. *Abdomen:* sternum 5 with posterior margin straight. *Legs:* metatibia straight, narrow at apex, apical mucro short, straight.

Distribution (Fig. 45). The type series of *A. berberidis* consists of adult specimens from the following localities. ARGENTINA. *Río Negro:* El Bolsón. CHILE. *Chiloé:* 19 km. S Ancud; 13 km. S Castro; Chepu; Dalcahue; Puerto Montt; 12 km. N Puerto Montt; Quellón. *Llanquihue:* Frutillar; 2 km. S Frutillar; Maullín. *Osorno:* Laguna la Copa and Laguna Espejo, Parque Nacional de Puyehue; Volcán Osorno.

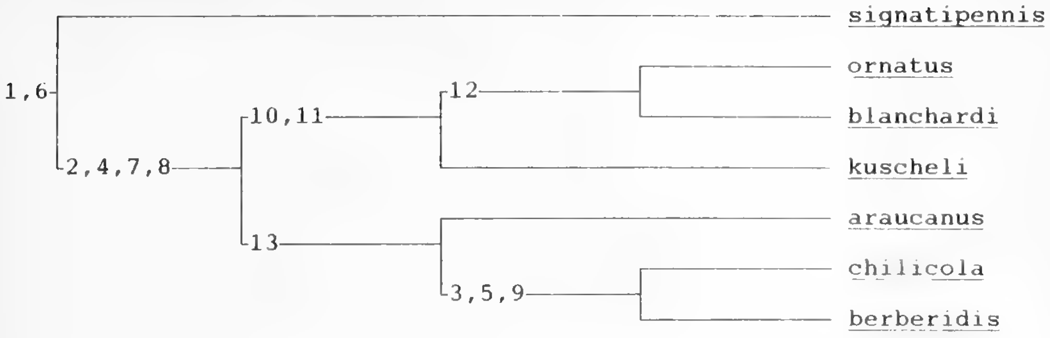
Plant associations. Specimens of *A. berberidis* were collected on *Berberis darwini* 19 km. S Ancud and at Chepu, Chiloé, and at Laguna la Copa and Laguna Espejo, Parque Nacional de Puyehue, Osorno, Chile. Label data indicate that adults have been collected in January, February, March, September, October, November and December.

Etymology. The name of this species is derived from that of the plant genus with which it and several other *A. ornatus* group members are associated.

## PHYLOGENY

The classification of the subfamily Anthonominae has been called "chaotic" (Burke 1976). Some 500, mostly New World, named species are assigned to the subfamily, but recent revisionary studies (Clark 1987a, b, c, 1988, Clark and Burke 1985, 1986a, b, c) indicate that the actual number of species may be twice that. Within this unwieldy mass of species, some apparently natural groupings do present themselves, but it is not often possible to identify the sister groups of these. This is the case with the *A. ornatus* group. The group seemed by preliminary inspection to be natural, but identification of the sister group remains for future studies. Thus, in order to apply the outgroup method of comparison to identify apomorphic characters in the *A. ornatus* group, it was necessary to attempt to identify characters unique to the group by examining a broad, though incomplete, array of anthonomine taxa. Further studies may reveal that some of these characters are more widely distributed.

The most detailed comparisons included those of characters of the *A. ornatus* group with those of anthonomines examined in connection with ongoing revisionary studies. These include the species in the *Anthonomus albolineatus, furcatus, grandis, gularis, unipustulatus,* and *venustus* groups, the species of the *Anthonomus* subgenera *Anthomorphus, Anthonomocyllus* and *An-*



**46**

Fig. 46. Phylogenetic tree depicting hypothesized relationships of the species of the *A. ornatus* group.

*thonomorphus,* the genera *Atractomerus, Loncophorus, Omogonus* and *Pseudanthonomus,* and the types of most of the named Neotropical Anthonominae. Numerous Nearctic and Old World species have also been examined, but not in as much detail. There is no indication that any of the species examined should be placed in the *A. ornatus* group, nor are there indications that any of them is the sister group of the *A. ornatus* group.

As a result of the comparisons made, 13 characters (listed below) were determined to be unique to adults of the *A. ornatus* group. The distribution of these characters among the seven species in the group is depicted in Table 1. Presence is indicated by a score of "1," absence by a score of "0," "missing," because the female of *A. chilicola* is unknown, by a score of 9. These characters were analyzed using the PAUP computer programs developed by Swofford (1985), on an IBP Personal Computer to determine the most parsimonious branching pattern consistent with this distribution of characters. Analysis of the 13 characters, all given equal weight, with the ALLTREES option which searches all possible trees, produced the phylogenetic tree depicted in Fig. 46. The characters, with comments on their distributions under the constraints of the accepted solution, are listed below.

1) Elytral integument with markedly contrasting patterns of pallid and dark portions clothed with correspondingly pallid and dark scales ranging from white through pallid to dark ferruginous to

Table 1. Data matrix for the phylogenetic tree in Fig. 46.

| | Characters | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |
| Outgroup | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *signatipennis* | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *ornatus* | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| *blanchardi* | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| *kuscheli* | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| *araucanus* | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *chilicola* | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 9 | 9 | 9 | 9 |
| *berberidis* | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |

fuscous (Figs. 1–12). Although contrasting patterns of light and dark integument and light and dark scales are not unique to the *A. ornatus* group, the patterns are similar in the species in the group and do not seem to be exactly duplicated in any of the other anthonomines.

2) Elytra with large, posterolateral maculae (Figs. 3–12). These are weakly developed in *A. araucanus* and *A. berberidis* (Figs. 7, 8, 11, 12).
3) Sutural elytral interstriae with acute, overlapping apical extensions.
4) Aedeagus with apicolateral prominences (Figs. 21, 23, 25, 27, 29). These are assumed to have been lost in *A. araucanus* (Fig. 28) and *A. berberidis* (Fig. 30).
5) Aedeagus asymmetrical (Figs. 29, 30).
6) Endophallus with an elongate, flat, distal sclerite (Figs. 19–30).
7) Endophallus with two dentate median sclerites (Figs. 27, 28). These are assumed to have been secondarily lost in the ancestor of *A. ornatus* and *A. blanchardi* and in that of *A. chilicola* and *A. berberidis.*
8) Parameres of tegmen of male genitalia close together or fused at base.
9) Metatibia of male with ventral margin strongly concave in distal ⅔, with enlarged, excavated, apical mucro.
10) Pygidium of female with subapical prominences (Figs. 14, 15). These are weakly developed and assumed to be obsolescent in *A. ornatus* (Fig. 14) and *A. blanchardi.*
11) Sternum 5 of female with apicomedian prominence. This is a simple prominence in *A. kuscheli,* a prominence bounded by shallow emarginations in *A. blanchardi* (Fig. 18), a long prominence bounded on each side by deep incisions in *A. ornatus* (Fig. 17).
12) Sternum 5 of female incised or emarginate (Figs. 17, 18).
13) Pygidium of female with apicomedian prominence (Fig. 16).

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# A REVIEW OF THE WORLD SPECIES OF *NOTOGLYPTUS MASI* (HYMENOPTERA: PTEROMALIDAE)

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*Abstract.*—Until the present review, *Notoglyptus* Masi was a monotypic genus containing the single species *N. virescens* Masi, which was known from throughout the Old World. This species is redescribed, and its known distribution is extended to the Nearctic region. Four new species of *Notoglyptus* from the New World are described: ***N. bidentatus, N. luteicrus, N. nesiotes*** and ***N. tzeltales.*** *Notoglyptus* is redescribed, its relationships to other genera of the Miscogasterinae are discussed, and a key is given for distinguishing the known world species. The host(s) of species in this genus are still unknown.

*Key Words:* Hymenoptera, Pteromalidae, *Notoglyptus,* Nearctic, Palearctic, Neotropics, taxonomy

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Masi (1917) described the genus *Notoglyptus* and included two species, *N. virescens* Masi from the Seychelles Islands, and *N. niger* Masi from Italy. He designated the latter species as the type-species of the genus. Boucek (1976) synonymized *N. niger* with *N. virescens.* This cosmopolitan species was by then known to occur throughout southern Europe, across to India, and down into southern Africa (Graham 1969, Boucek 1976). I have seen specimens from Japan and a single male from North America. During the course of sorting collections for a continuing study of the Nearctic miscogasterine Pteromalidae, I came across specimens belonging to four undescribed species of *Notoglyptus* from the New World—*N. bidentatus* n. sp. from South America, *N. tzeltales* n. sp. from Central America and northern South America, *N. luteicrus* n. sp. from the continental Nearctic region south to Venezuela, and *N. nesiotes* n. sp. from the Caribbean and coastal southeastern U.S.

Graham (1969) placed *Notoglyptus* in the Sphegigasterini (Miscogasterinae), probably because the elongate T1 is found in other genera he placed there such as *Cryptoprymna* Förster and *Novitzkyanus* Boucek. Genera with an elongate T1 occur sporadically throughout the Pteromalidae, and I feel its common occurrence in these three genera is due to convergence (Heydon 1988). The closest relatives of *Notoglyptus* are among genera related to *Halticoptera* Spinola and *Thinodytes* Graham. These genera all share a similar unique propodeal structure—the median panels of the propodeum are reticulately sculptured or smooth and have a distinct median carina and plicae connected posteriorly by a W-shaped carina (compare Figs. 12 and 13). This carina is most distinctly developed in *N. bidentatus* and *N. tzeltales,* the most morphologically generalized *Notoglyptus* species. The terminal two segments of the maxillary palps of male *Halticoptera* are lamellately expanded, and this character state also occurs in *Notoglyptus luteicrus* (Fig. 11). However, using this character state as direct evidence for a close relationship between *Halticop-*

*tera* and *Notoglyptus* is complicated because *N. luteicrus* is one of the more morphologically derived members of the genus; this character state is not present in the more primitive extant species of *Notoglyptus.*

The characters defining *Notoglyptus* are reviewed in the Discussion section following the generic description below. *Notoglyptus* may have evolved in South America since that is where the most primitive species (*N. bidentatus* and *N. tzeltales*) are found.

## MATERIALS AND METHODS

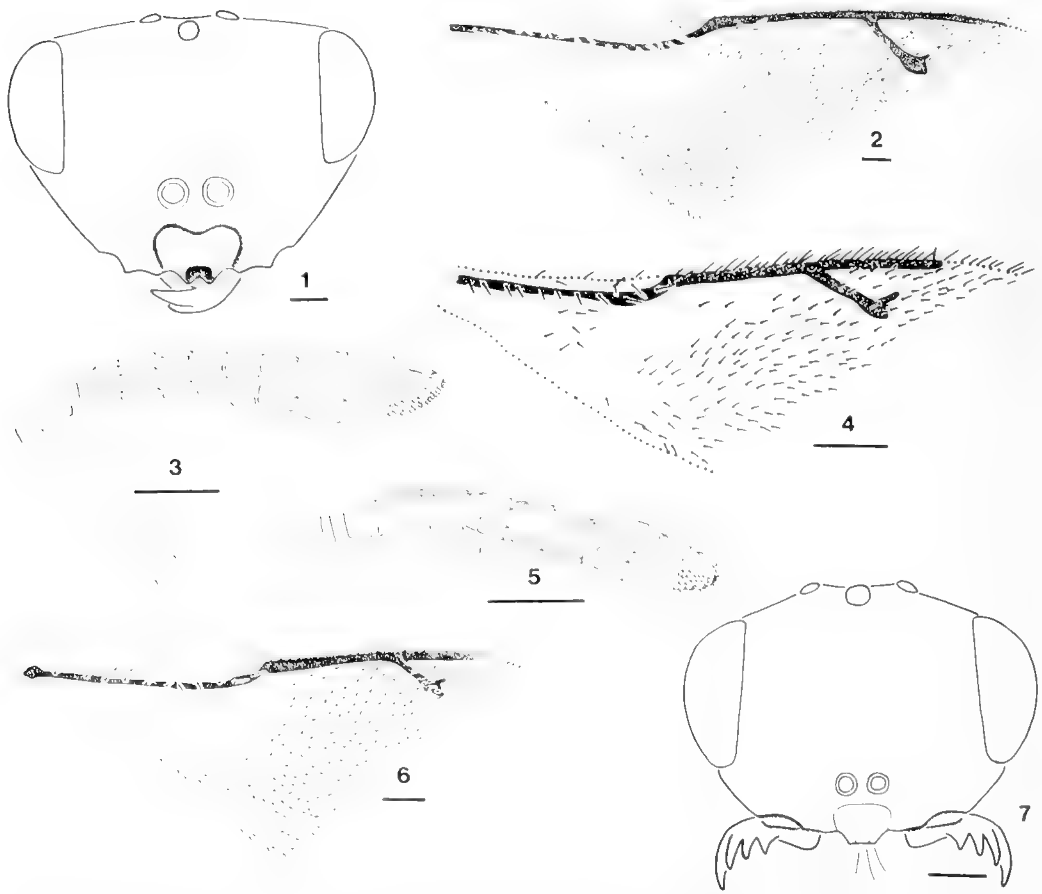
This study is based on examination of 67 specimens from the museums whose acronyms are given in the Acknowledgment section below. Type depositions are given in parentheses in the appropriate section under each species description. Terminology in this paper generally follows that of Graham (1969), except that club is used instead of clava and the gastral terga are numbered 1–7 starting with the basal tergite of the gaster. The following abbreviations are used: the multiporous plate sensillae are MPP sensillae, the lower ocular line is LOcL, the antennal funicular segments are F1, F2, . . , F6, and the gastral terga are T1, T2, . . ,T7. The units of measurement given in the descriptions can be converted to millimeters by multiplying by 0.02.

## ***Notoglyptus*** **Masi**

*Notoglyptus* Masi, 1917: 181. Type species *N. niger* Masi (original designation). Gahan and Fagan, 1923: 98. Peck, Boucek, and Hoffer, 1964: 36 (key). Graham, 1969: 124 (key), p. 140. Boucek, 1976: 15. Dzhanokmen, 1978: 77 (key), p. 80. Farooqi and Subba Rao, 1985: 259, 310F, 310G; 1986: 295.

Description. Color: Body ranges from black to metallic green or blue; legs metallic or entirely nonmetallic. Structure: Head ovate (Fig. 7) or triangular (Fig. 1) in anterior view; clypeus with anterior margin straight or produced (Fig. 7), bidentate in *N. bidentatus* (Fig. 1); genal concavities well developed, extending ½ to ⅓ malar length. Antenna inserted near or below LOcL; with 2 anelli, 6 funicular segments, and 3-segmented club; MPP sensillae in 1 row on each funicular segment (Figs. 3, 5); club often with micropilosity on terminal segment(s) (Figs. 3, 5), apical spine not present. Mesosoma with pronotum reduced, much narrower and depressed relative to mesoscutum (Figs. 8, 10, 12), horizontal collar developed in *N. bidentatus* (Fig. 8), *N. tzeltales,* and *N. virescens* but not present in *N. luteicrus* (Fig. 10) and *N. nesiotes* (Fig. 12), this collar bordered anteriorly by weak to strong anterior transverse carina; mesoscutum with notauli complete, groovelike (Figs. 8, 10, 12); upper epimeron smooth; scutellum with scutoscutellar sulcus foveolate medially in *N. nesiotes* (Fig. 12) and *N. virescens,* frenal sulcus distinct (Figs. 8, 10, 12), frenum weakly coriaceous or smooth; propodeum with median panels alveolate or smooth, plicae and median carina distinct, connected posteriorly by W-shaped carina (Fig. 9). Wing hyaline; relative lengths of veins as submarginal > marginal > postmarginal > stigmal; basal cell and vein setate (Figs. 2, 4) except in *N. tzeltales* (Fig. 6); fore wing sometimes with distinct admarginal setae. Petiole quadrate to elongate, granulate to alveolate; median carina sometimes present; basal flange present. Gaster ovate; T1 nearly concealing succeeding terga, hind margin straight; hypopygium extending nearly to tip of gaster. Male maxillary palps pale in all species except *N. bidentatus*; terminal two segments lamellately expanded in *N. luteicrus* (Fig. 11).

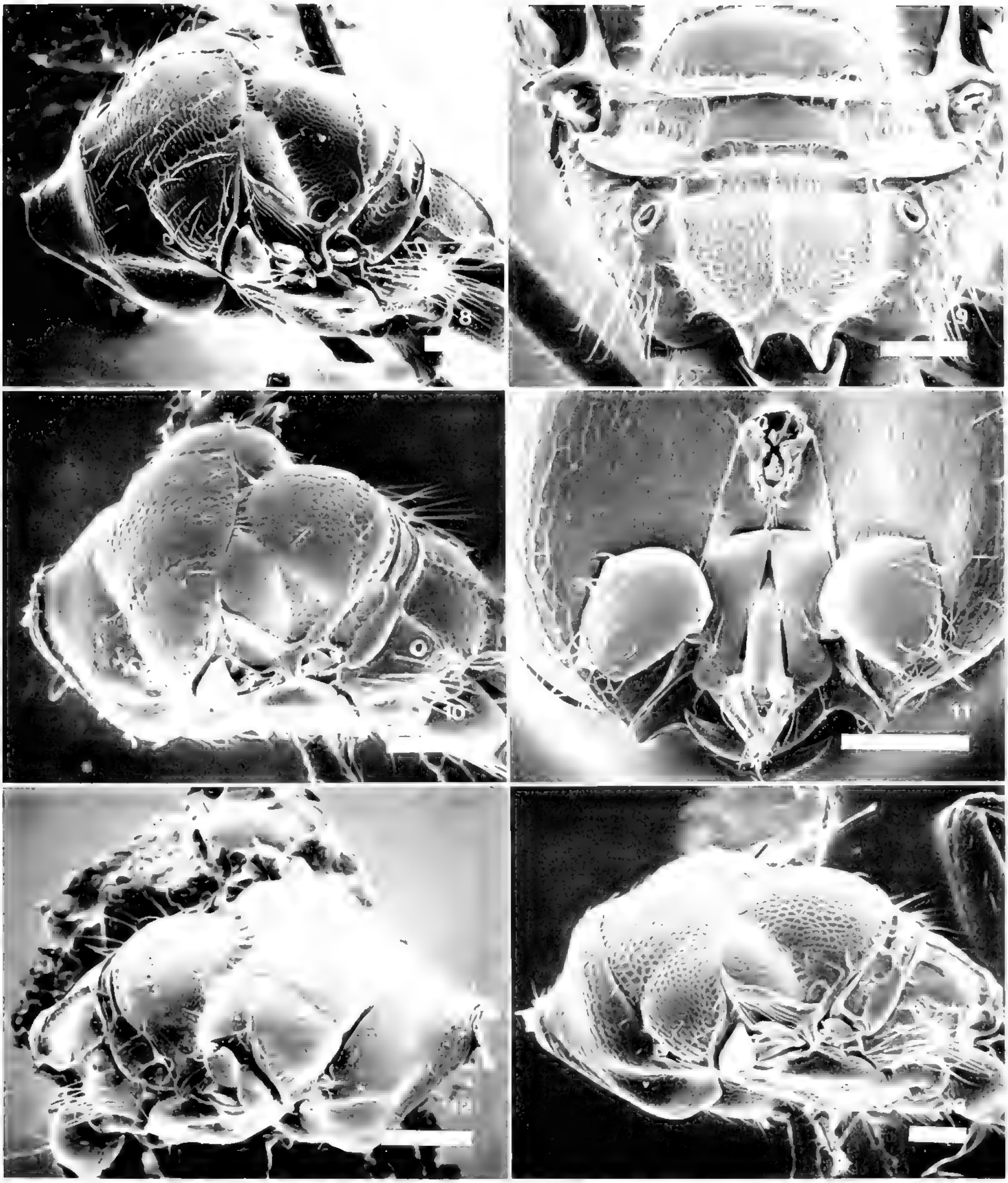
Discussion. The following combination of character states will reliably distinguish *Notoglyptus*: the presence of distinct genal concavities; a 13-segmented antenna; complete, groovelike notauli (Figs. 8, 10, 12); the propodeum with the median carina and plicae distinct, and connected posteriorly by W-shaped carina (Fig. 9); the petiole about as long as wide, with a basal ventral flange;



Figs. 1–7. 1–2, *Notoglyptus bidentatus* n. sp., male. 1, Anterior view of head. 2, Fore wing. 3, *Notoglyptus luteicrus* n. sp., female. 3. Antenna. 4–5, *Notoglyptus nesiotes* n. sp., female. 4, Fore wing. 5, Antenna. 6–7, *Notoglyptus tzeltales* n. sp., female. 6, Fore wing. 7, Anterior view of head.

T1 almost completely covering the entire length of gaster, with its hind margin entire; and the hypopygium extending to the tip of the gaster. An autapomorphy defining *Notoglyptus* is the reduction in size of the pronotum relative to the rest of the mesosoma. This character is easily seen in comparison with other closely related miscogasterine genera such as *Halticoptera* (compare Figs. 8, 10, 12 with 13). The unique fovea in the center of the scutellum so prominent in the type species is clearly of no more than specific value when looking at this genus on a worldwide basis.

The species of *Notoglyptus* can be divided into two distinct species-groups. *Notoglyptus bidentatus* and *N. tzeltales* comprise the first group which is characterized by a large body size, the body and legs with extensive bright metallic coloration, the anterior margin of the clypeus produced (Figs. 1, 7), the toruli located below the LOcL (Figs. 1, 7), the female antennal club with no micropilosity, the fore wing lacking any distinct admarginal setae, and the petiole without a median carina. Except possibly for the low insertion of the antennae, these characters states are all plesiomorphic compared with those defining the other species-group. *Notoglyptus luteicrus, N. nesiotes,* and *N. virescens* form the second species-group. These species are relatively small, have the



Figs. 8–13. 8–9, *Notoglyptus bidentatus* n. sp., male. 8, Dorsolateral view of mesosoma. 9, Frenum, dorsellum, and propodeum. 10–11, *Notoglyptus luteicrus* n. sp., male. 10, Dorsolateral view of mesosoma. 11, Maxillary palps. 12, *Notoglyptus nesiotes* n. sp., female. 12, Dorsolateral view of mesosoma. 13, *Halticoptera* sp., female. 13, Dorsolateral view of mesosoma. Scale bar = 0.1 mm.

body color very dark, the legs (including the coxae) yellow and nonmetallic, the anterior margin of the clypeus nearly straight, the toruli located above the LOcL, the female antennal club with micropilosity, the fore wing with distinct admarginal setae, and the petiole with a median carina.

Despite these obvious morphological differences, the species I have placed together in *Notoglyptus* belong together as a monophyletic unit within the Miscogasterinae on the basis on the reduced size of the pronotum, and with respect to closely related genera such as *Halticoptera,* because of the elongate first gastral tergite and hypopygium. Division of the two species-groups into separate genera would result in the species-group containing *Notoglyptus bidentatus* and *N. tzeltales* being paraphyletic. Further, the important character of the presence or absence of the horizontal pronotal collar cuts across the species-groups as I have outlined them here. *Notoglyptus virescens* has a horizontal collar as do *N. bidentatus* and *N. tzeltales*; yet, in the characters separating the species-groups, *N. nigrescens* belongs with *N. luteicrus* and *N. nesiotes.*

## KEY TO WORLD SPECIES OF *NOTOGLYPTUS* MASI

1. Pronotum lacking horizontal collar, sloping downward immediately from anterior margin of mesoscutum (Figs. 10, 12) .............. 2.
– Pronotum with short horizontal collar separated from declivitous neck by a weak to strongly developed transverse carina (Fig. 8) .. 3.
2. Scutellum with a pair of diverging foveae at base (Fig. 12). Dorsellum cariniform. Female antenna with funicular segments 5–6 quadrate to elongate (Fig. 5). (West Indies and coastal southeastern United States) .... *nesiotes* Heydon
– Scutellum with scutoscutellar sulcus a continuous deep furrow, not foveolate (Fig. 10). Dorsellum bandlike, length nearly half that of frenum. Female antenna with funicular segments 5–6 transverse (Fig. 3). (Continental North America south to Venezuela) .. *luteicrus* Heydon
3. Scutellum with discal fovea. Torulus above lower ocular line. Coxae and femora yellow, nonmetallic .................... *virescens* Masi
– Scutellum smoothly convex (Fig. 8). Torulus below lower ocular line (Figs. 1, 7). Coxae and femora blue or green, metallic. (Neotropical) .. 4.
4. Head triangular in anterior view; anterior margin of clypeus bidentate (Fig. 1). Basal cell of fore wing setate (Fig. 2). Body length 2 mm or more. (South America) ...... *bidentatus* Heydon
– Head ovate in anterior view; anterior margin of clypeus truncate (Fig. 7). Basal cell of fore wing bare (Fig. 6). Body length 1.8 mm or less. (Central America and northern South America) ......................... *tzeltales* Heydon

## *Notoglyptus bidentatus*, NEW SPECIES

Figs. 1–2, 8–9

Holotype, female. Description. Color: Head dark green; mesosoma mostly dark green with strong coppery reflections on dorsum and upper epimeron; pronotum, propodeum, petiole, gaster bluish black. Antenna with scape, pedicel dark green; flagellum black. Maxillary palp brown. Legs with coxae dark blue; fore, middle trochanters orange-yellow, hind trochanter brown; femora blue-green, orange-yellow basally and apically; tibiae orange-yellow basally, remainder orange-brown with weak metallic reflections medially; tarsi dark brown. Wing veins brown.

Sculpture: Clypeus, gena finely coriaceous; head finely alveolate otherwise. Mesosoma (Fig. 8) with middle lobe of mesoscutum alveolate; side lobes, scutellum, frenum (weakly) finely coriaceous; dorsellum smooth; median panels of propodeum alveolate (Fig. 8); petiole finely alveolate, alveoli 2× as long as wide; gastral terga smooth.

Structure: Body length 2.4 mm. Head (Fig. 1) triangular in anterior view, width 1.4× height (46:34), 2.2× length (46:21); clypeus separated from face by deep furrowlike carina, anterior margin produced and bidentate; genal concavity shallow, extending ⅓ malar distance; frons regularly concave between eyes; eye height 1.4× length (16.5:12.0), 1.1× malar length (16.5:15.0), eye length 1.5× temple length (12:8); ratio of MOD, OOL, POL, LOL as 3:11:8:4. Antenna with torulus one inside diameter beneath LOcL; combined length of pedicel and flagellum 0.85× head width (39:46); relative lengths of scape, pedicel, anelli, F1–6, club as 22.0:7.0:3.0:4.0:4.5:4.0:4.0:4.0:3.5:7.0; widths of F1, F6, club as 3:5:5; second anellus 2× as large as first; club without micropilosity. Mesosoma (Fig. 8) length 1.6× width (59:36); collar with weak anterior transverse carina; scutellum regularly rounded, scutoscutellar sulcus continuous furrow; dorsellum bandlike, length equal to frenal length; spiracles ovate, <1 × own diameter from anterior margin of propodeum; nucha bordered by carina anteriorly. Fore wing (Fig. 2) length 2.3× width (145:63); ratio of submarginal, marginal, postmarginal, stigmal vein lengths as 50.0:30.0:24.0:13.5; costal cell densely setate; basal cell setate to base along anterior margin; speculum closed posteriorly; no distinct admarginal setae present. Petiole broadening apically, length 1.8× apical width (15.0:8.5); lacking median carina. Gaster length 1.4× width (42:30); deep, height 1× width (30:30).

Allotype, male. Color: Similar to holotype female except front of head blue-green with violet reflections, anelli and funicular segments tan ventrally. Structure: Body length 2.4 mm. Antenna with combined length of pedicel and flagellum 0.93× head width (40:43); lengths of scape, pedicel, anelli, F1–6, club as 20:5:3:4:4:4:4:4:4:9; widths of F1, F6, club as 3.5:4.0:4.0; funicular segments tend to be hemispherical. Maxillary palps slender. Petiole length 2.2× width (15.5:7.0). Gaster length 1.3× width (37:28).

Variation. The body length of the paratype males ranges between 2.1 and 2.8 mm. Though all the paratype males were collected from approximately the same area, they show considerable variation in color. Most are basically green like the allotype, but one is blue, and several of the others have greater or smaller areas of the head and mesosoma purple. One male has a petiole only 1.4 times as long as wide; the petiole of the other males ranges between 1.8 and 2.3× as long as wide. The basal cell varies from totally setate, as in the holotype, to two specimens which have only a couple of rows of setae along the anterior margin of the basal cell.

Discussion. Unique features of this species are the triangular head (Fig. 1), the broad and deep antennal scrobes, the long malar distance, the bidentate clypeus (Fig. 1), the deep sulcus around the clypeus (Fig. 1), and the dark maxillary palps. *Notoglyptus bidentatus* exhibits a few primitive character states not found in congeners. It has a distinct pronotal collar (Fig. 8) (a character state shared with *N. tzeltales* and *N. virescens*), a bidentate clypeus, and dark maxillary palps. The extensively setate wings (Fig. 2) may also be primitive. However, setate wings are common in miscogasterine species living at high elevations or latitudes, so it is difficult to say in this case whether the setate wings of *N. bidentatus* are primitive or an adaptation to the mountainous habitats where this species occurs.

Etymology. The specific name is from the Latin word *bidentatus,* meaning two-toothed, and refers to the unique bidentate state of the anterior margin of the clypeus in this species.

Biology. Nothing is known of the host(s) of this species.

Type material. The holotype, allotype, and 5 male paratypes (all CNC) were collected in Ecuador in the elfin forest at 3800 meters along the Quito-Baeza Road on 1 March 1979 by W. Mason. Four additional paratypes (CNC, INHS, USNM) were collected as follows: Ecuador. Napo (4100 m, Quito-Baeza Road), 24·II·1983, 1 ♂, Paruma (4200 m, Quito-Baeza Road), 14–17·II·1982, 3 ♂.

### *Notoglyptus luteicrus,*
### NEW SPECIES

Figs. 3, 10–11

Holotype, female. Description. Color: Head, mesosoma, petiole black, except the following blue: clypeus; pairs of diffuse spots extending anteriorly from lateral ocelli; vertex along orbits; lateral parts of pronotum and mesoscutum, frenum, dorsellum, propodeum; pleural regions posteriodorsally. Gaster brown, T1 with bluish reflections. Antenna with scape yellow-brown, darker in apical ⅕; pedicel brown; flagellum dark brown. Mandibles yellow, teeth reddish yellow. Maxillary palps yellow. Legs yellow, pretarsi dark brown. Wing veins pale brown.

Sculpture: Clypeus smooth; remainder of head, mesoscutum (Fig. 10), scutellum delicately alveolate; frenum coriaceous (Fig. 10); dorsellum smooth; median panels of propodeum alveolate, pattern very weak in center of each panel; petiole granulate; gastral terga smooth.

Structure: Body length 1.4 mm. Head ovate in anterior view, width 1.3× height (27:21), 2.2× length (27:12); clypeus set off from face by obscure sulcus, anterior margin straight; genal concavity extending halfway to eye; antennal scrobes shallow; eye height 2.4× length (13.0:5.5), 2.2× malar length (13:6), length 4.9× temple length (9.5: 2.0); ratio of MOD, OOL, POL, LOL as 1.5: 5:6.5:3. Antenna (Fig. 3) with torulus one outside diameter above LOcL; combined length of pedicel and flagellum 0.93× head width (25:27); relative lengths of scape, pedicel, anelli, F1–6, club as 13.0:4.0:1.0:2.0: 2.5:2.0:2.0:2.0:1.5:8.0; widths of F1, F6, club as 2.0:3.5:4.0; anelli subequal in size; micropilosity completely covering ventral side of terminal segment. Mesosoma length 1.4× width (28:20); collar undeveloped; scutellum regularly rounded, scutoscutellar sulcus continuous furrow; dorsellum length ½ frenal length; spiracles round, 1× own diameter from anterior margin of propodeum; nucha acarinate anteriorly. Fore wing length 3.1× width (65:21); ratio of submarginal, marginal, postmarginal, stigmal vein lengths as 20:11:9:6; costal cell with single complete row of setae; basal vein with row of 4 setae; basal cell with 1 seta on left wing; speculum open posteriorly; 1 row of distinct admarginal setae present. Petiole length 1.1× width (4.5:4.0); median carina present. Gaster ovate, length 1.4× width (29:21); height 0.86× width (18:21).

Allotype, male. Description. Color: Similar to holotype except reflections of frenum, dorsellum, propodeum green. Structure: body length 1.4 mm. Antenna with combined length of pedicel and flagellum 1.2× head width (31.0:26.5); relative lengths of scape, pedicel, anelli, F1–6, club as 14:3:1: 3:3:3:3:3:3:9; widths of F1, F6, club as 2:3: 3. Maxillary palps (Fig. 11) with 2 apical segments lamellately expanded. Petiole length 1.2× width (6:5). Gaster length 1.4× width (22:16).

Variation. Body size in the females ranges from 1.0 to 1.5 mm; in the males, 1.2 to 1.4 mm. The patches of metallic coloration on the head and mesosoma vary among specimens in extent, intensity, and color. The color varies from blue, as in the holotype, to dark green. The specimens from the eastern U.S. and Canada usually have the scape brown only at the apex, but those from Mexico and the western U.S. and Canada have the scape mostly brown. The setal patterns of the wings are variable, but the wings generally resemble that in Fig. 4.

Discussion. The unique feature of this species is the lamellately expanded male maxillary palps (Fig. 11). Within its species-group, *Notoglyptus luteicrus* resembles *N. nesiotes* in lacking any horizontal collar on the pronotum (Fig. 10) and a patch of micropilosity on the apical segment of the female club (Fig. 3). *Notoglyptus luteicrus* has spots of metallic coloration located in similar places to those in *N. nesiotes* but the boundaries of the spots on the head are diffuse in *N. luteicrus* and sharp in *N. nesiotes.*

Etymology. The specific name comes from the Latin words *luteus,* meaning yellow, and *crus,* meaning leg, and refers to the yellow legs of this species.

Biology. Nothing is known of the host(s) of this species, but specimens have been collected from alfalfa, soybeans, *Baccharis* L. (Compositae), and the crucifers *Sisymbrium altissimum* L. and *Descurainia sophia* (L.) P. B. Webb.

Type material. The holotype (INHS) was collected from the railroad siding at the end of Gerty Drive on the South Farms of the University of Illinois, Champaign County, Illinois, on 25 June 1982, by S. L. Heydon. The allotype (INHS) came from the same locality, but was collected 21 August 1981. Eighteen additional paratypes were collected as follows (AMNH, CNC, INHS, SEC, USNM): Canada. ALBERTA: Lethbridge, 5·VII·1956, (swept from brome) 2 ♀; Lost River, Onefour (10 mi. WNW Wild Horse), 3·VI·1956, 1 ♀. ONTARIO: 13 mi. N Belleville, 27·V·1970, 1 ♀. United States. CALIFORNIA: Rancho Santa Fe, 14·I·1959, (alfalfa field) 1 ♀. COLORADO: Fort Collins, V·1894, (alfalfa) 1 ♂. FLORIDA: Collier Seminole State Park (Collier Co.), 25–26·V·1978, 1 ♀; Fort Ogden, 8·IV·1952, 1 ♀. IDAHO: Hansen, 29·V·1930, (*Sisymbrium altissimum* and *Descurainia sophia*) 1 ♀. INDIANA: Hovey Lake (Posey Co.), 3·VI·1981, 1 ♂. ILLINOIS: Dixon Springs Agricultural Research Station (Pope Co.), 29–31·VII·1980, 1 ♂. LOUISIANA: Cameron Parish, 4·VIII·1969, (soybeans) 1 ♀. MARYLAND: Patuxent Research Center (Prince Georges Co.), 1·VIII·1982, 1 ♀. NEW JERSEY: Ramsey, 31·VII·1918, 1 ♀. NEW MEXICO: Elmendorf, 21·VII·1936, 1 ♀. UTAH: Richfield, 18·V·1954, 1 ♀; Utah Lake (Utah Co.), 1 ♀. Mexico. VERACRUZ: Jalapa, III–IV·1965, 1 ♀. Venezuela. PORTUGUESA: 10 km N Biscucuy, 9·VI·1981 (sweeping *Baccharis*), 1 ♂. Country? San Rafael Jicoltepec, 1 ♀, 3 ♂.

### *Notoglyptus nesiotes*, New Species

Figs. 4–5, 12

Holotype, female. Description. Color: Head, mesosoma, petiole black except propodeum metallic coppery; inner orbit along vertex, area between median and lateral ocelli, pronotum and mesoscutum laterally, posteriodorsal pleural region metallic green. Gaster dark reddish brown with coppery reflections dorsally. Antenna with scape, anelli yellow; pedicel, flagellum brown. Mandibles yellow, teeth reddish yellow. Maxillary palps yellow. Legs yellow, pretarsi black. Wing veins yellow, parastigma darker.

Sculpture: Body sculpture weak, face coriaceous, mesoscutum (Fig. 12) weakly alveolate mesally, petiole granulate, body nearly smooth otherwise.

Structure: Body length 1.4 mm. Head ovate in anterior view, width 1.4× height (22:16), 2.2× length (22:10); clypeus separated from face by obscure sulcus, anterior margin straight; antennal scrobes shallow; genal concavity weakly developed, extending only ⅓ of way to eye; eye height 1.2× length (9.0:7.5), 2.0× malar length (9.0:4.5), eye length 3.8× temple length (7.5:2.0); ratio of MOD, OOL, POL, LOL as 1.5:5:5.5:3. Antenna (Fig. 5) with torulus 1× own outside diameter above LOcL; combined length of flagellum and pedicel 1.0× head width (23:22); relative lengths of scape, pedicel, anelli, F1–6, club as 10.5:3.5:1.0:2.0:2.0:2.0:2.0:2.5:2.0:6.0; widths of F1, F6, club as 1.5:2.0:2.0; anelli subequal in size; club with patch of micropilosity down ventral side of apical segment. Mesosoma (Fig. 12) length 1.7× width (26:15); collar not developed; scutellum uniformly convex, scutoscutellar sulcus with pair of contiguous diverging foveae mesally; dorsellum carinalike; spiracles 1.5× own diameter from anterior margin of propodeum, nucha bordered by carina anteriorly. Fore wing (Fig. 4) length 2.7× width (48:18); submarginal, marginal, postmarginal, stigmal vein lengths as 17.0:11.5:7.0:5.0; costal cell with one complete row of setae plus a few others distally; basal vein setate; speculum open posteriorly; distinct row of admarginal setae present. Petiole length 0.88× width (3.5:4.0); median carina present. Gaster ovate, length 1.4× width (25:18); height 1.0× width (18:18); T2–7 protruding from beneath T1.

Male unknown.

Variation. The specimens in the type series from Isla Mona are all of a rather uniform size, coloration, and morphology. The number of setae along the basal vein varies from just a couple of setae to a row extending down the length of the basal cell and curving basally down the cubital vein. About half the specimens have a few setae distally in the basal cell. The paratype female from Sapelo Island, Georgia, lacks the metallic patches on the head and is more distinctly sculptured than the series from Isla Mona. Its body sculpturing resembles that given above for *N. luteicrus.* It also resembles *N. luteicrus* in lacking the distinct carina along the anterior margin of the nucha. However, it has long terminal funicular segments of the antenna, a foveolate scutoscutellar sulcus (Fig. 12), and a cariniform dorsellum, features which are all diagnostic for *N. luteicrus.* Collection of specimens from a wider geographic range may help make sense of the morphological divergence between the populations from Puerto Rico and those of the continental U.S.

Discussion. Unique features of this species are the weak body sculpture (Fig. 12) and the cariniform dorsellum (Fig. 12). *Notoglyptus nesiotes* and *N. virescens* both have terminal funicular segments of the antenna quadrate or elongate and a foveolate scutoscutellar sulcus, but *N. nesiotes* lacks the fovea on the disc of the scutellum characteristic of *N. virescens.*

Etymology. The species name is derived from the Greek word *nesiotes,* meaning insular, and refers to the island distribution of this species.

Biology. The host(s) of this species are unknown. The paratype female from Sapelo Island, Georgia, was collected on *Spartina* Schreber (Gramineae).

Type material. Holotype (USNM) and 8 paratype females (CNC, USNM) were collected on Isla Mona, Puerto Rico, in August 1944, by H. A. Beatty. One additional paratype female was collected as follows: United States. GEORGIA: Sapelo Island (Mcintosh Co.), 10·IX·1963 (on *Spartina*).

### *Notoglyptus tzeltales*, New Species

Figs. 6–7

Holotype, female. Description. Color: Front of head dull dark green; vertex, dorsum of mesosoma blue-green; propodeum, pleural regions, coxae green; petiole bluish black; gaster dark reddish brown with strong bluish reflections. Antenna with scape blue-green; remainder brown, pedicel with weak metallic reflections. Mandibles brownish yellow; teeth pale brownish red. Maxillary palps cream-colored. Legs with most of femora brown with weak metallic reflections; tibiae brownish yellow, slightly darker mesally; basal tarsal segment brownish yellow, rest of tarsi darkening distally till pretarsus black. Wing veins reddish brown.

Sculpture: Clypeus granulate; head, mesosoma, scutellum regularly alveolate; frenum, dorsellum, propodeum smooth; petiole finely strigulate dorsally; gaster smooth.

Structure: Body length 1.6 mm. Head (Fig. 7) broadly ovate in anterior view, width 1.3× height (32:24), 2.1× length (32:15); clypeus separated from face by distinct sulcus, anterior margin produced but truncate; antennal scrobes shallow; genal concavity extending ½ way to eye; eye height 1.3× length (14:11), 1.8× malar length (14:8), length 3.7× temple length (11:3); ratio of MOD, OOL, POL, LOL as 2.5:6:6:3. Antenna with torulus located just below LOcL; combined length of pedicel and flagellum 0.72× head width (23:32); relative lengths of scape, pedicel, anelli, F1–6, club as 14.0: 4.5:1.5:2.0:2.0:2.0:2.0:2.0:2.0:5.0; relative widths of F1, F6, club as 2.0:3.0:3.5, all funicular segments except F1 transverse; anelli subequal in size; club lacking ventral patch of micropilosity. Mesosoma length 1.4× width (34:24); collar developed, anterior edge rounded; scutellum regularly convex, scutoscutellar sulcus continuous furrow; dorsellum length about ½ frenal length; spiracles ovate, <1× own diameter from anterior margin of propodeum; carina bordering nucha anteriorly. Fore wing (Fig. 6) length 2.2× width (71:33); ratio of submarginal, marginal, postmarginal, stigmal vein lengths as 28:18:8.5:6; costal cell with one complete row of setae and couple of others distally; basal cell and vein bare;

speculum open posteriorly; no distinct admarginal setae. Petiole length 1.6× width (8:5); lacking median carina. Gaster ovate, length 1.7× width (30:18); deep, height 1× maximum width (18:18).

Allotype, male. Color: Pattern similar to holotype but antenna beyond basal half of pedicel nonmetallic, brownish yellow; club slightly darker on outer side. Body length 1.5 mm (critical point-dried). Antenna with combined length of pedicel and flagellum 0.73× head width (20.5:28.0); relative lengths of scape, pedicel, anelli, F1–6, club as 12:3:1:2:2:2:2:2:2:5; relative widths of F1, F6, club as 2:3:3; funicular segments cylindrical. Maxillary palps slender. Petiole length 2.0× width. Gaster length 1.6× width (31:20).

Variation. The color of *N. tzeltales* varies greatly over its geographic range. The female from Huetamo de Nuñez is almost black except for the dorsum of the mesosoma which is dark green, and the antennal flagellum is yellow beyond the basal half of the pedicel. The male has the face violet, the remainder of the head and mesosoma green, the pedicel to F6 yellow, and the club brown. Females of the series from Venezuela have the body greenish black and the antennal flagellum brown. In the males, one paratype has antennal coloration like that of the allotype, while the other has the flagellum brown on the outer face and pale on the inner face. The males from Venezuela also have the tip of the middle tibia darkened. The Venezuela series was collected into alcohol and then critical point-dried. This process can sometimes alter the colors of specimens. Whether the color differences in *N. tzeltales* are caused by environmental influences or genetic differences needs study.

Discussion. Unique features of *N. tzeltales* are the bare basal cell and vein (Fig. 6). This species most closely resembles *N. bidentatus* in having metallic legs and the anterior margin of the clypeus produced; although in *N. tzeltales* (Fig. 7), the clypeus does not have the median emargination present in *N. bidentatus* (Fig. 1). The two species are reliably distinguished by the characters given in the key.

Etymology. The specific name of this species comes from the Tzeltales Indians who live in the area of Mexico around San Cristóbal de las Casas.

Biology. The host(s) of this species is unknown.

Type material. The holotype (CNC) is from San Cristóbal de las Casas, Mexico, and was collected 1–3 June 1969. The allotype male and 8 female and 2 male paratypes (USNM) were collected in Venezuela, 10 km north of Biscucuy, on 9 June 1981, by E. E. Grissell, while sweeping *Baccharis* (Compositae). Ten female and 1 male paratypes were collected as follows (CNC, USNM): Costa Rica. Cartago (1500 m), VIII·1980, 1 ♀; Heredia, 10·VIII·1975, 2 ♀. Mexico. CHIAPAS: San Cristóbal de las Casas, 27·IV·1969, 2 ♀, 12·VI·1969, 1 ♀. MICHOACAN: Huetamo de Nuñez, 7·III·1972, 1 ♀, 1 ♂. QUERETARO: 10 mi. E San Juan Del Río, 30·VII·1954, 2 ♀. Guatemala. GUATEMALA: Guatemala City, IX·1959, 1 ♀.

### ***Notoglyptus virescens* Masi**

*Notoglyptus virescens* Masi, 1917: 181–183. Gahan and Fagan, 1923: 98. Boucek, 1961: 67. Graham, 1969: 140. Boucek, 1976: 15 (synonymy). Boucek, Subba Rao, and Farooqi, 1978: 448. Farooqi and Subba Rao, 1986: 295. Holotype, ♀, BMNH Hym. 5.873 (examined).

*Notoglyptus niger* Masi, 1917: 181. Erdös, 1948: 38. Boucek, 1961: 67. Peck et al., 1964: 36. Boucek, 1976: 15 (synonymy). Farooqi and Menon, 1973: 55. Boucek, 1977: 46. Dzhanokmen, 1978: 80. Boucek et al., 1978: 448.

The following description of *N. virescens* is based on a pair of specimens on loan to me from the BMNH.

Female. Description. Color: Head, mesosoma, petiole dark green; gaster brown. Antenna with scape yellow, slightly more brown apically; remainder brown, pedicel pale ventrally. Mandible yellow, teeth reddish brown. Maxillary palps yellow. Legs yellow. Wing veins yellowish brown.

Sculpture: Clypeus smooth, remainder of head delicately alveolate; mesoscutum roughly alveolate medially, becoming coriaceous laterally; scutellum coriaceous; frenum, dorsellum smooth; median panels of propodeum alveolate, sculpturing weak in center of panels; petiole alveolate; gaster smooth.

Structure: Body length 1.3 mm. Head ovate in anterior view, width 1.3× height (23.5:18.0), 2.0× length (23.5:11.5); clypeus separated from face by obscure sulcus, anterior margin nearly straight, slightly reflexed; antennal scrobes shallow; genal concavity extending ½ way to eye; eye height 1.4× length (11:8), 2.8× malar length (11:4), length 2.7× temple length (8:3); ratio of MOD, OOL, POL, LOL as 2.0:4.5:6.0:3.0. Antenna with torulus 1× own diameter above LOcL; combined length of pedicel and flagellum 1.1× head width (25.0:23.5); relative lengths of scape, pedicel, anelli, F1–6, club as 11.0:3.0:1.0:2.0:2.5:2.5:2.5:2.5:2.5:7.0; relative widths of F1, F6, club as 1.75:2.0:2.0; anelli subequal in size; micropilosity in line down ventral side of terminal two segments of club. Mesosoma length 1.5× width (28:19); horizontal collar developed, anterior edge carinate; scutellum with distinct discal fovea, scutoscutellar sulcus foveolate medially; dorsellum length ½ frenal length; propodeum with spiracles circular, 1.5× own diameter from anterior margin of propodeum; nucha not bordered by carina anteriorly. Fore wing length 2.5× width (57:23); ratio of submarginal, marginal, postmarginal, stigmal vein lengths as 20:12:9:5; costal cell with 1 complete setal row basally and a couple others apically; basal cell with apical quarter setate; speculum closed posteriorly; distinct admarginal setae present. Petiole length 1.2× width (5:4); with weak median carina. Gaster length 1.3× width (21:16); height 1.1× width (17:16).

Male. Color: Similar to female except face with face bluish, dorsum of mesosoma greenish. Structure: Body length 1.0 mm. Antenna with combined length of pedicel and flagellum 1.5× head width (31:21); relative lengths of scape, pedicel, anelli, F1–6, club as 10.0:2.5:1.0:3.0:3.0:3.0:3.0:3.5:3.0:8.0; relative widths of F1, F6, club as 2:2:2. Maxillary palps slender. Gaster length 1.5× width (27:18).

Variation. The male from Ontario is a little larger (body length 1.3 mm), its scape is mostly brown, its legs are more amber, and its petiole lacks the median carina; but agrees otherwise with the above description.

Discussion. Unique features possessed by this species are the fovea on the disc of the scutellum and the club having a line of micropilosity down the ventral side. This species is intermediate in morphology within the genus since it has the developed horizontal pronotal collar like *N. bidentatus* and *N. tzeltales,* but has the straight clypeal margin, the toruli located above the LOcL, the antennal club with micropilosity, yellow legs, admarginal setae, and a median carina on the petiole like *N. luteicrus* and *N. nesiotes.*

Distribution. This species is found from southern Europe to India, Japan, and southern Africa (Boucek 1976, 1977). There is a male in the Canadian National Collection from Mount Pakenham, Ontario.

Material Examined (BMNH, CNC). India. Delhi, IMRI, 1·IV·1977, (on grass) 1 ♀. Zimbabwe. Salisbury, 1 ♂. Japan. KYOTO: Kibune, 6·VIII·1980, 1 ♀. Canada. ONTARIO: Mount Pakenham, 11·VI·1969, 1 ♂.

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# BOOK REVIEW

*Bees of the New Genus* Ctenoceratina *in Africa South of the Sahara (Hymenoptera: Apoidea).* By Howell V. Daly. University of California Publications in Entomology 108: 1–69. February 1988. University of California Press.

Once again, Howell Daly has prepared an excellent taxonomic revision. This monograph of the new genus *Ctenoceratina* Daly and Moure (tribe Ceratinini) encompasses 13 species of small carpenter bees indigenous to subsaharan Africa. Included are a new subgenus, *Simioceratina* Daly and Moure, and three new species, *Ctenoceratina malindiae* Daly, *C. paulyi* Daly, and *C. rossi* Daly. A key, synonymies, descriptions, distributions (precise, but unfortunately without locality maps), and some biological data including parasites are provided.

The publication's format provides a clear, easily followed explanation of how and why various taxonomic decisions were made. Thus, the text will prove useful to both experienced and novice hymenopterists. The high quality illustrations include SEM photographs (Figs. 1–8) and line drawings (Figs. 9–50). One minor complaint is that figure numbering (particularly of facing plates pp. 64–65) is not consistently from left to right or from top to bottom. The left to right convention seems most easily followed.

Dr. Daly's thorough approach to this study is evidenced by his efforts to assess variability. Through rearing, careful observation of live material, and collection at select localities, he documented striking allometric differences among nest mates, and among individuals within local populations. (Such differences undoubtedly led earlier taxonomists to distinguish some 55 species.) When large series were available, an effort was also made to assess variation between populations. I appreciated Dr. Daly's treatment of species displaying complex geographic variation. Rather than designating formal subspecies, informal "forms" were discussed for these polytypic species. I also appreciated the clarity provided by his "similar species" discussions contained within the species descriptions.

A critical test of the key was never made since our African material was still on loan to Dr. Daly. However, the key was easily read and the illustrations made interpretation appear straight forward. One point of potential confusion that should be noted is his use of the term "scale." The genus name, *Ctenoceratina,* was selected because of the comb-like rows of enlarged setae ("scales") found on the apical edges of terga and sterna 2–4 and frequently 5. While not incorrect, this usage might momentarily baffle the unsuspecting bee worker who dives into the key without previously reading the introduction.

Reviewing this work whetted my appetite for future investigations of *Ctenoceratina.* We are indebted to Howell for providing yet another valuable contribution.

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PROC. ENTOMOL. SOC. WASH.
91(1), 1989, p. 125

## Book Review

*Control of Arthropod Pests of Livestock: A Review of Technology.* By Roger O. Drummond, John E. George, and Sidney E. Kunz. 1988. CRC Press, Inc., Boca Raton, Florida, 245 pp. Price US $125.00.

This book reviews a large number of papers published in the U.S. and Canada concerning the materials and methods which have been used to control arthropod pests of livestock. It is principally a summary of the history of chemical treatments. It is not a manual of pest control techniques, nor is it a treatise on the evolution and/or failures of chemical insecticides or acaracides which have been used against pests of livestock. The book covers the entire spectrum of arthropod pests of livestock. The material reviewed on the biology and significance of each pest ranges from one to two pages and the review of control technologies used against each pest ranges from three to sixteen pages.

The first 15 chapters are arranged by commodity, i.e. cattle, horses, sheep and goats, swine and poultry, and each chapter is subdivided into sections on individual pests. The biology and importance of each pest is discussed briefly, followed by a two-to-seven page review of control efforts, and each chapter is summed up by an Overview and Current Technology section. The overview sections are well done and provide a concise and valuable statement of current control methods for each pest group.

Chapters 16 through 18 review the control efforts which have been used against pests that breed in poultry manure, against ticks and chiggers and against flies in livestock manure and around structures. These chapters are well arranged but the five-to-nine pages devoted to each subject necessarily limit the number of papers and technologies reviewed.

Chapter 19 provides a 4-page review of pest resistance to insecticides and is probably the most disappointing chapter in the book, particularly in view of the emphasis that the authors place on the historical usage of chemicals as insecticides and acaracides.

Chapter 20 provides a nice review of the major sterile insect release programs (6 pages) and chapter 21 reviews the status of biocontrol technology (5 pages).

Chapter 22 provides an intriguing preview of the possibilities of developing the resistance of livestock to arthropod pests (5 pages).

There is a 4-page appendix which lists the trade and chemical names of many of the insecticides and acaracides mentioned in the book, but no addresses are listed for the manufacturers of the chemicals.

Although a large number of references are listed for each pest, the list is, of necessity, incomplete and even some bibliographies (i.e. West, West and Peters) are not mentioned. There are no lists of the published bibliographies or reviews of literature pertaining to an individual pest or commodity except for the sterile insect technique for screwworms.

There are no charts, chronological lists of control methods (except for cattle grubs), or analyses of the histories of the development of resistance of pests to chemicals.

In summary, this is an ambitious book which meets the stated objectives of the authors to provide a history of control technologies. It should be of interest to anyone who is interested in the history of livestock pest control methods and should be valuable as a background source to anyone who is just entering the livestock pest control field. In my opinion, however, it is grossly overpriced at U.S. $125.00.

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PROC. ENTOMOL. SOC. WASH.
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# Book Review

*Ecological Methods with Particular Reference to the Study of Insect Populations.* T. R. E. Southwood. 1978. Second revised edition. Chapman and Hall, London, New York; xxiv + 524 pp. $32.50 Softcover.

This second edition, now available in paperback, is a thoroughly updated version of the first edition from 1966. Some chapters have been completely or largely rewritten and substantial new information has been added. Most impressively, and vividly illustrating the rapid growth of available ecological information, close to a thousand new references have been included. The book presents a synthesis of "methods that are peculiar to the ecologist," and especially those aimed at the study of insect populations. The usage, however, is much broader as techniques generally applied to the study of earthworms, mollusks, nematodes, planktonic organisms, and several non-insect arthropods have been included. The approach is mainly syn-ecological and only little attention has been paid to the habitat although the importance of spatial and temporal heterogeneity as well as predictability is stressed. The first chapter is introductory and discusses classification of population estimates, errors and confidence, and chapter 2 deals with the sampling program and the description of population dispersion. Chapters 3–8 are mainly aimed at the question of how to obtain an absolute population estimate and contain marking techniques, capture-recapture methods, and sampling procedures. Chapters 9–11 deal with demographical aspects. In chapter 12 systems analysis and modelling are briefly discussed, and the realm of community ecology is reached in chapter 13 which deals with diversity, species packing and habitat. The last chapter discusses productivity and energy budgets.

'Ecological Methods' spans the gap between suction traps made from homestyle vacuum cleaners and, for example, the "linear dioristical [systems] model with algebraically defined transfer functions." To attain this, a lot of information has to be presented in a fairly condensed state, but Southwood manages to do this in a very coherent and readable style.

Sampling techniques are discussed thoroughly and their strengths and weaknesses with regard to their ease, the samples they produce and the financial resources they demand are stressed. Much attention is paid to possible sources of errors, whether stemming from the equipment proper or from the heterogeneity and unpredictability of living organisms or their habitats. Basic mathematical and statistical theory is not discussed at length but is still presented in a very clear form and with ample references for those interested in its derivation.

It is, perhaps, somewhat ironical that a book devoted to the study of populations does not provide an explicit discussion on how to define a population as a spatiotemporal entity. Largely left unanswered are questions like: How are geographical limits defined?, which constituing features emerge?, and, what are the temporal dimensions?

A decade has passed since the 1978 edition, and methods and theory in insect ecology have kept evolving. Emerging fields as tropical rainforest canopy ecology have developed largely new techniques, and much new information is available on patterns of population growth, e.g. how to predict insect pest outbreaks using integrated trapping with various combinations of pheromones, kairomones, colors, and host-mimic lures. The need for precision and critical cost/benefit considerations, however, remains important, and it is still imperative to be able to evaluate the limitations and possible biases of the techniques involved in any study. Therefore, the book still stands out as a must for anyone teaching the practical aspects of insect (or animal) ecology, and as an extremely valuable manual for all who need to investigate animal populations, whether as a research ecologist, a conservationist or an applied entomologist.

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## NOTE

# Rediscovery of the Ant *Gnamptogenys hartmani* (Hymenoptera: Formicidae) in Eastern Texas

Wheeler (1915. Bull. Amer. Mus. Nat. Hist. 34: 390) described *Gnamptogenys hartmani* from a single worker collected in Huntsville, Walker Co., eastern Texas. This record seemed anomalous for a genus otherwise confined to tropical environments (Brown. 1961. Psyche 68: 69). Brown (op cit) suggested that the Texas record was either a locality error or an adventive specimen taken from bananas (it also occurs in Honduras). There are no ecological data associated with the specimen. Brown (op cit) concluded that the presence of *Gnamptogenys* in Texas remained to be convincingly demonstrated.

We have collected a second worker specimen from Texas, Brazos Co., 10 km N of Kurten, about 60 km west of the type locality. The specimen was collected in a pitfall trap in an open grassy area located 30 meters from dense post oak (*Quercus* spp.) woods on 5 Aug. 1987 (trap was in field for 24 h). Although we did extensive pitfall trapping, baiting, general collecting and berlese funnel sampling of the litter in the study area, we have not collected any additional specimens. We have not collected this species in several other similar areas in eastern Texas, using similar methods. This specimen was collected in a disturbed area (mowed and occasionally grazed by cattle), but the ant was definitely not associated with any introduced products. These data, in addition to the collection of this species in Louisiana (Echols. 1964. Ann. Entomol. Soc. Amer. 57: 137) clearly demonstrate that this species is a rarely collected member of the fauna of the United States. This species preys on the brood of the ant *Trachymyrmex septentrionalis* (McCook) (Echols op cit), which is common in the area. The ant, *Atta texana* (Buckley), is also common and may serve as a prey species.

It is gratifying that this interesting element of our native ant fauna has withstood the onslaught of the spread of the imported fire ant (*Solenopsis invicta* Buren), which eliminates many native ant species. The ant was collected in an area of sandy soil where the density of the imported fire ant is relatively low (115 mounds/ha). The specimen is in the collection of WPM, field number 9676.

Alex Mintzer suggested the study area, O. L. Tate gave us permission to use the area, Mark Strain, Shelley Stonecipher and Cecil Pinder assisted with the field work. The research was supported by the Texas Department of Agriculture. This report is approved as Number TA 23642 of the Texas Agricultural Experiment Station.

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1884

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# THE UNIQUE PURRING SONG OF *CHRYSOPERLA COMANCHE* (BANKS), A GREEN LACEWING OF THE *RUFILABRIS* SPECIES GROUP (NEUROPTERA: CHRYSOPIDAE)

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*Abstract.*—The courtship song of *Chrysoperla comanche,* a common green lacewing from western North America, is described and compared to that of its apparent closest relative, *C. rufilabris.* It was found to consist of a single long (about 15 seconds) volley of abdominal vibration, producing a substrate-borne signal that steadily increased in amplitude from beginning to end. Its primary frequency averaged about 87 Hz at 27°C, and was modulated in amplitude by simultaneous low frequency vibrations caused by slower oscillations of the abdomen. Both sexes made identical calls, and each female answered the male's signal halfway through his song. Temperature affected the song's phenotype, so linear regression equations were used to compare features at any temperature. Unique song characteristics shared between *C. comanche* and its sister species, *C. rufilabris,* reflect their close relationship and phylogenetic distinctness from the *Chrysoperla carnea* group.

*Key Words:* Chrysopidae, *Chrysoperla,* courtship, acoustical, communication

The green lacewing taxon *Chrysoperla* Steinmann has recently been accorded full generic status (Séméria 1977), yet further subdivision may be necessary to represent the evolutionary divergence that has occurred within its boundaries. Currently, the genus is defined by morphology, bionomics, and behavior: its members share a common ground plan of male genitalia and wing venation, feed as adults principally on honeydews rather than plant lice, overwinter as diapausing adults, and must "sing" to one another before mating (Séméria 1977, Hagen and Tassan 1966, Sheldon and MacLeod 1974, Henry and Johnson in press). However, more careful scrutiny of genitalia in particular indicates that at least two natural species groups of *Chrysoperla* can be recognized (Agnew et al. 1981, Adams pers. commun.). The better studied of these, the *carnea* group (Tauber and Tauber, 1987), includes the common North American species *C. plorabunda* (Fitch), *C. downesi* (Banks), and *C. mohave* (Banks). The other group, known as the *rufilabris* group, is characterized by male genitalia that are unique among *Chrysoperla*; its members are most easily recognized by their relatively narrow, apically pointed hind wings, and by the bright red stripe usually present on the facial area (genae) of the head. *Chrysoperla rufilabris* (Burmeister), *C. harrisii* (Fitch), *C. externa* (Hagen), and *C. comanche* (Banks) belong to this lineage.

Singing during courtship and mating is a characteristic of all *Chrysoperla* species, and has been studied in both of the species groups. These songs are actually bouts or volleys of male or female abdominal quivering/jerking that vibrate leaves, twigs, or conifer needles with substrate-borne, low frequency signals (Henry 1979)—a phenomenon known as tremulation. The signals display complex frequency and amplitude modulation and are highly consistent and unique within each species. Both sexes sing, reciprocally exchanging their signals in prolonged duets, and in most species, the two sexes produce identical songs (Henry 1980a, b, c, 1985a). Within the recognized and undescribed species of the *carnea* group in North America and Europe, the songs have been shown to have a species-isolating effect, preventing hybridization between otherwise interfertile cryptic species (Henry 1985a, b, 1986).

The *rufilabris* group of *Chrysoperla* may also use vibrational calls in this way, but only the common *C. rufilabris* has been analyzed in any detail (Henry 1980a). Here, I describe the peculiar tremulating songs of the sister species of *C. rufilabris, C. comanche,* from two sites in California. This species was originally described from Texas and is found throughout southwestern North America (Bickley and MacLeod 1956, Agnew et al. 1981). It is a common resident of orchards and vineyards at low elevation and occurs sympatrically with *C. rufilabris* at many localities. Just as *C. rufilabris* has song features not found in the *carnea* group, the call of *C. comanche* is of most unusual design and dynamics, reflecting and reinforcing the distinct phylogenetic position of the *Chrysoperla rufilabris* lineage.

## METHODS AND MATERIALS

I collected adults of *Chrysoperla comanche* at two sites in California, 220 km apart, during late September, 1987. Twelve were obtained in the early afternoon of 24 September, 1987, from the southern tip of Sequoia National Forest, two kilometers south of Isabella Lake, Kern County, at an elevation of about 1000 meters. The collecting area was very dry and hot (34°C), with scattered 5–10 meter-tall scrub oak (*Quercus dumosa* Nuttall) and larger (to 20 meters) digger pine (*Pinus sabiniana* Douglas). All were flushed from the oaks by prodding the branches with an insect net. Twenty-one other adults were obtained from a citrus grove just northeast of the town of Mentone, San Bernardino County, at about 500 meters elevation. These were collected at dusk (26°C) by beating the branches of 8 meter-tall lemon trees. Phillip Adams (California State University, Fullerton) chose this second site and assisted in procuring and identifying the insects there. All were mailed to my laboratory in Connecticut. The specimens from each population were maintained as a separate breeding colony, referred to as Isabella or Mentone. Adults were supplied with a water and Wheast® diet (Hagen and Tassan 1966, Henry 1983b). Eggs were removed daily and larvae reared on ether-killed *Drosophila* spp., as described in Henry (various papers). Photoperiods of 17:7 daylight : darkness and temperatures of 25 ± 1°C resulted in rapid growth and continual reproduction in the laboratory. Several field-collected individuals were tested for reproductive and singing behavior, but the majority of tests were performed on first and second laboratory generations. The songs of six males and seven females from Isabella Lake and three males and one female from Mentone were analyzed in detail. Of these, one male and two females from Isabella Lake and one male and one female from Mentone were original, field-caught individuals.

Adult males showed courtship activity within 24 hours of eclosion, and females after three days. Therefore, tests were initiated on week-old individuals, and continued for about one month (lifespan averaged 140 days). During testing, each lacewing was placed individually or with a partner in a small cardboard coffee cup covered with plastic wrap. Vibrations from abdominal jerking were monitored from the plastic surface with a piezoelectric transducer connected to a Tektronix® digital oscilloscope, amplifier/speaker, and cassette tape record-er, as described in earlier papers (Henry 1985a, b).

For analysis, recorded signals were digitized by a Cambridge Electronics Design CED1401 12-bit A/D,D/A device and transferred to an IBM PC-AT microcomputer. Multiple-slice fast-Fourier transforms (FFT's) and accurate measures of elapsed time could then be performed on the signals with the WATERFALL® software package of Cambridge Electronics Design, Ltd. Frequency and time data were keyed into the spreadsheet, Microsoft EXCEL®, for further analysis and reduction, and could then be transferred (through ASCII and DIF file conversion) to programs like Asyst Software Technologies' ASYSTANT+® for statistical analysis or Jandel's SIGMAPLOT® and Advanced Graphics Software's SLIDEWRITE for graphing.

A lacewing song (= call) is a vibrational entity that an individual produces once or at irregular intervals. Each may consist of one, or many, volleys (= bouts) of abdominal vibration, and those volleys are organized into "shortest repeated units" (SRU's), composed of at least one but often several volleys delivered with some consistent temporal spacing. During a duet, each participant repeatedly answers its partner with the SRU characteristic of the species. In *C. comanche,* the song is best described as a single volley, so the terms song, call, volley, bout, and SRU are synonyms.

Because the features of lacewing songs vary with temperature, data were collected at 20 to 28°C to calculate linear regression equations. Results could then be normalized to a standard temperature, 27°C, to compare means and standard deviations among different subsets of data or between taxa. I measured eight major features (Tables 1, 2, 3, and Fig. 1) of the songs of *C. comanche,* using 71 male and 89 female volleys at 8 different temperatures. These features were specifically chosen to facilitate comparison with *Chrysoperla rufilabris* (Table 3; Figs. 1, 2, 5; Henry 1980a). To compare the slopes of the temperature regressions of different song features or different populations or taxa, $Q_{10}$ (the factor by which a feature changes over a 10°C rise in temperature) was determined for each song component. This factor is obtained by calculating the expected value of the feature at 20 and 30°C from the linear regression and dividing the larger value by the smaller (Table 4).

Significant differences were recognized where the means of two normally distributed samples differed from one another by a two-tailed t-test using confidence limits of 99% or better. These are marked in the tables with triple asterisks (***). Values following a ± sign are one standard deviation of the mean.

Voucher specimens were deposited in the entomological collection of the University of Connecticut. Some were frozen at −90°C for future protein and DNA analysis.

## RESULTS

Mating in *C. comanche,* as in other lacewings of the genus *Chrysoperla,* was preceded by a long, well-defined courtship in which the partners exchanged volleys of abdominal vibration. These songs, usually produced spontaneously and identically by both males and females under a wide range of temperature and light conditions, occurred most often at 25°C or above and during the last hour of daylight. Individuals also sang in response to the call of another insect, or to a recorded or synthesized song of the correct structure and duration played through a small (12 cm) loudspeaker. The shortest repeated unit (SRU) of the song consisted of a single prolonged volley of abdominal vibration, lasting about 15 seconds at 27°C (Fig. 1; Tables 1, 2, 3). The song, when heard through headphones, resembled a long, drawn out "purr" that began at the threshold of audibility and slowly built to a crescendo, then diminished quickly at its conclusion with one or two secondary bursts of vibration. The fundamental or pri-

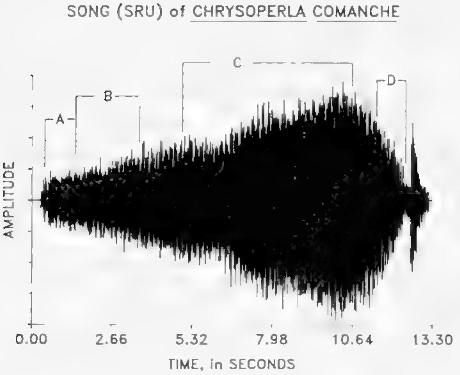

Fig. 1. Digitized oscillograph of the shortest repeated unit (SRU or volley) of the call of *Chrysoperla comanche*, showing principal parameters A–D defined in text and referenced in tables. A, initial volley frequencies; B, early middle volley frequencies; C, late middle volley frequencies; D, end-of-volley frequencies.

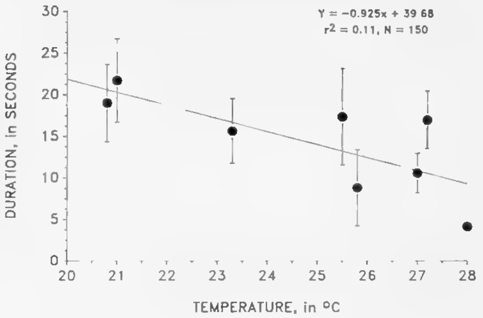

Fig. 3. Effect of temperature on volley duration for all calls of all males and females of *Chrysoperla comanche*. The filled circle at each temperature is the mean of at least 15 volleys delivered at that temperature, and the error bars bracket one standard deviation of the mean. The linear regression equation, its squared variance, and its sample base are entered above the line plot.

mary frequency of vibration averaged 86–88 Hz during the major, central portion (B and C of Fig. 1) of each volley. Each call started (A) and ended (D) at slightly but significantly lower frequencies of about 75 and 79 Hz, respectively (Table 3). In addition, the primary frequency was modulated by a lower frequency, high amplitude oscillation whose frequency similarly increased, leveled off, and then decreased during the course of each volley. The mean of this modulation frequency was about 21 Hz, but started at approximately 14 Hz and stopped at 17.5 Hz (Table 3). It was clear from watching receptive lacewings at low temperatures that this modulating oscillation corresponded to gross vertical movements of the insect's abdomen, while the higher, primary frequency was produced by a low-amplitude abdominal "buzzing" superimposed on the low-frequency carrier (Fig. 2). At high temperatures, primary and modulating frequencies were both high enough and of sufficiently low amplitude to render the motions of the abdomen nearly invisible.

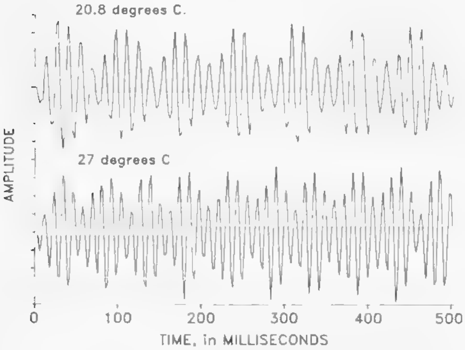

Fig. 2. Digitized oscillographs of half-second fragments of songs produced at two different temperatures by a solo female *Chrysoperla comanche*. Spikes within a volley are strokes of the individual's abdomen and constitute the primary frequency of the call. The regular variations in overall amplitude are caused by the modulating frequency.

Males and females sang identically, in every respect (Tables 1, 2, 3). In 27 of 36 observed heterosexual duets, the female answered a spontaneous call produced by the male well before the male completed his song. When the female finished, a few seconds passed before the male initiated another volley, and then the female again began to sing partway through the male's song. Thus *C. comanche* duets were not "polite," in the sense of nonoverlapping. In fact, the beats that were produced from the acoustical interaction between two su-

Table 1. Principal characteristics of the songs of individual males of *Chrysoperla comanche*, normalized to 27°C. Means and standard deviations are tabulated, with the number of measured volleys entered parenthetically. Averages and standard deviations of the means are shown in the bottom rows. The letters A to D refer to the parts of the song specified in Figure 1.

| | Males | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Abdominal Vibration Frequency (strokes/second) | | | | Modulation Frequency (maxima/second) | | | Song Duration (seconds) |
| Indiv. | Initial (A) | Mid1 (B) | Mid2 (C) | End (D) | Initial (A) | Mid (C) | End (D) | |
| 1 | — | 91.63 | 90.82 | 88.14 | 12.84 | 22.79 | 20.76 | 18.16 |
| | — | ± 1.35 | ± 1.37 | ± 2.20 | — | ± 0.43 | ± 1.47 | ± 5.65 |
| | — | (7) | (7) | (7) | (1) | (7) | (5) | (7) |
| 2 | — | 90.38 | 87.15 | 85.01 | 15.34 | 22.72 | 21.20 | 21.60 |
| | — | ± 1.13 | ± 0.05 | ± 0.50 | — | ± 0.45 | ± 0.00 | ± 4.19 |
| | — | (4) | (4) | (4) | (1) | (4) | (4) | (4) |
| 3 | 77.72 | 88.11 | 86.88 | 81.86 | 12.87 | 19.70 | 16.09 | 11.15 |
| | ± 4.16 | ± 2.41 | ± 3.00 | ± 3.11 | ± 1.64 | ± 1.02 | ± 1.44 | ± 4.17 |
| | (4) | (8) | (9) | (9) | (4) | (8) | (6) | (9) |
| 4 | 77.56 | 86.64 | 85.55 | 81.10 | 8.35 | 20.85 | 17.09 | 17.99 |
| | ± 3.13 | ± 2.33 | ± 1.21 | ± 2.69 | — | ± 0.75 | ± 1.77 | ± 3.58 |
| | (12) | (16) | (16) | (11) | (1) | (16) | (2) | (15) |
| 5 | 70.16 | 89.56 | 87.48 | 81.03 | — | 21.74 | 18.56 | 18.01 |
| | — | ± 0.73 | ± 0.47 | ± 4.32 | — | ± 0.37 | ± 1.61 | ± 5.43 |
| | (1) | (6) | (6) | (4) | — | (6) | (3) | (4) |
| 6 | 72.17 | 90.86 | 87.79 | 77.01 | — | 20.54 | — | 16.29 |
| | ± 5.91 | ± 2.19 | ± 1.52 | ± 5.91 | — | ± 0.94 | — | ± 6.00 |
| | (4) | (5) | (5) | (4) | — | (5) | — | (5) |
| 7 | 75.92 | 86.18 | 83.98 | 80.47 | 16.20 | 21.93 | 20.13 | 17.14 |
| | ± 0.00 | ± 3.40 | ± 1.78 | ± 0.76 | ± 4.24 | ± 0.39 | ± 3.02 | ± 10.52 |
| | (2) | (7) | (7) | (7) | (5) | (7) | (6) | (7) |
| 8 | 68.28 | 85.17 | 84.99 | 72.51 | 14.51 | 20.13 | 16.11 | 13.56 |
| | ± 5.12 | ± 1.08 | ± 1.24 | ± 2.01 | ± 2.36 | ± 0.68 | ± 1.53 | ± 3.29 |
| | (11) | (11) | (11) | (11) | (5) | (11) | (11) | (11) |
| 9 | 73.92 | 89.71 | 85.63 | 81.09 | — | 22.25 | 18.33 | 18.06 |
| | ± 2.45 | ± 2.28 | ± 0.33 | ± 3.20 | — | ± 0.43 | ± 1.42 | ± 4.84 |
| | (5) | (6) | (6) | (6) | — | (6) | (6) | (6) |
| Avg: | 73.68 | 88.69 | 86.70 | 80.91 | 13.35 | 21.41 | 18.53 | 16.88 |
| SD: | 3.66 | 2.27 | 1.99 | 4.42 | 2.79 | 1.14 | 2.02 | 3.00 |
| N: | 7.00 | 9.00 | 9.00 | 9.00 | 6.00 | 9.00 | 8.00 | 9.00 |

perimposed tones of similar but not identical frequency were very audible over headphones during the overlapping phases of the songs. One to ten of such sequences always occurred before copulation. Just prior to copulation, the distinctions between male and female calls became unclear: in five observed copulations, each partner sang without pause during the final 15 seconds of courtship, producing a cacophony of substrate-borne noise. The last phase of courtship was also characterized by a five to ten second period of wing bumping and mutual abdominal tapping, as in *C. rufilabris* and most other lacewing species.

Insects were tested and measured at a number of different temperatures. Data for three of the eight principal song features are graphed against temperature in Figs. 3 and 4, with the linear regression equations placed

Table 2. Principal characteristics of the songs of individual females of *Chrysoperla comanche*, normalized to 27°C. Means and standard deviations are tabulated, with the number of measured volleys entered parenthetically. Averages and standard deviations of the means are shown in the bottom rows. The letters A to D refer to the parts of the song specified in Figure 1.

| | Females | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Abdominal Vibration Frequency (strokes/second) | | | | Modulation Frequency (maxima/second) | | | Song Duration (seconds) |
| Indiv. | Initial (A) | Mid1 (B) | Mid2 (C) | End (D) | Initial (A) | Mid (C) | End (D) | |
| 1 | — | 89.40 | 88.50 | 85.75 | — | 22.03 | — | 17.01 |
| | — | ± 1.96 | ± 1.13 | ± 1.40 | — | ± 0.58 | — | ± 6.15 |
| | — | (3) | (3) | (2) | — | (3) | — | (3) |
| 2 | 78.59 | 86.90 | 85.69 | 82.04 | 13.14 | 21.49 | 16.64 | 7.69 |
| | ± 2.80 | ± 1.56 | ± 0.95 | ± 3.37 | ± 2.72 | ± 0.33 | ± 2.27 | ± 4.60 |
| | (5) | (6) | (6) | (6) | (3) | (6) | (6) | (6) |
| 3 | 79.72 | 88.17 | 86.75 | 83.29 | 13.34 | 20.75 | 19.12 | 13.56 |
| | ± 3.46 | ± 1.60 | ± 1.02 | ± 2.96 | ± 3.54 | ± 1.34 | ± 2.10 | ± 2.67 |
| | (4) | (9) | (9) | (6) | (2) | (9) | (4) | (9) |
| 4 | 76.49 | 86.50 | 84.89 | 76.10 | 14.23 | 21.25 | 16.01 | 11.91 |
| | ± 2.94 | ± 1.14 | ± 0.89 | ± 3.33 | ± 2.87 | ± 0.35 | ± 1.63 | ± 3.85 |
| | (16) | (22) | (22) | (22) | (6) | (22) | (22) | (20) |
| 5 | 72.58 | 86.85 | 85.31 | 78.46 | 15.34 | 21.27 | 18.36 | 16.48 |
| | ± 4.31 | ± 1.69 | ± 1.14 | ± 3.35 | ± 1.28 | ± 0.48 | ± 1.45 | ± 3.27 |
| | (9) | (18) | (18) | (18) | (3) | (18) | (17) | (17) |
| 6 | 73.66 | 88.68 | 84.90 | 79.53 | — | 21.41 | 17.09 | 12.07 |
| | — | ± 1.75 | ± 1.60 | ± 1.91 | — | ± 0.41 | ± 0.42 | ± 6.05 |
| | (1) | (4) | (4) | (4) | — | (4) | (4) | (4) |
| 7 | 70.61 | 90.09 | 88.19 | 79.31 | — | 19.76 | 16.75 | 16.39 |
| | ± 4.10 | ± 2.25 | ± 1.33 | ± 2.51 | — | ± 0.32 | ± 1.11 | ± 2.67 |
| | (5) | (10) | (10) | (9) | — | (10) | (9) | (10) |
| 8 | 81.00 | 87.42 | 84.52 | 78.10 | 12.56 | 21.56 | 17.33 | 11.39 |
| | ± 1.65 | ± 2.66 | ± 1.36 | ± 1.99 | ± 1.81 | ± 0.74 | ± 1.16 | ± 6.62 |
| | (10) | (17) | (17) | (15) | (5) | (15) | (12) | (14) |
| Avg: | 76.09 | 88.00 | 86.09 | 80.32 | 13.72 | 21.19 | 17.33 | 13.31 |
| SD: | 3.91 | 1.31 | 1.55 | 3.14 | 1.09 | 0.68 | 1.07 | 3.21 |
| N: | 7.00 | 8.00 | 8.00 | 8.00 | 5.00 | 8.00 | 7.00 | 8.00 |

beside each graph. Volley/SRU duration (Fig. 3) varied inversely with temperature, but the correlation was not very good: the regression coefficient, $R^2$, was a low 0.11. All primary and modulating frequency components (Fig. 4) showed a direct, linear temperature relationship, and those in the middle portions of the call were tightly correlated with temperature changes ($R^2 = 0.84$ to 0.85). The $Q_{10}$ values calculated from the regression equations (Table 4) were statistically equivalent for all frequency components of the calls. Compared with *C. plorabunda* and *Chrysopiella minora* Banks, however, pitch alterations of the songs of *C. comanche* were less pronounced for a given temperature change.

The temperature regression equations allowed conversion of all measured values to their equivalents at 27°C. Individual lacewings varied little in their normalized average values for most of the principal song features (Tables 1 and 2). When different populations of insects were compared (Table 3), males were insignificantly different from females, and Isabella Lake individuals

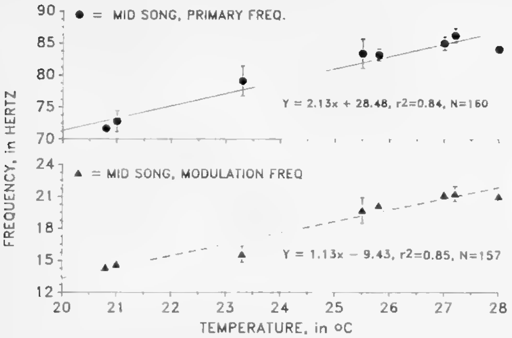

Fig. 4. Effect of temperature on the primary and modulation frequencies of the mid-volley portion of the songs of all males and females of *C. comanche*. The filled circle or triangle at each temperature is the mean of at least 15 volleys delivered at that temperature, and the error bars bracket one standard deviation of the mean. The linear regression equation, its squared variance, and its sample base are entered below each line plot.

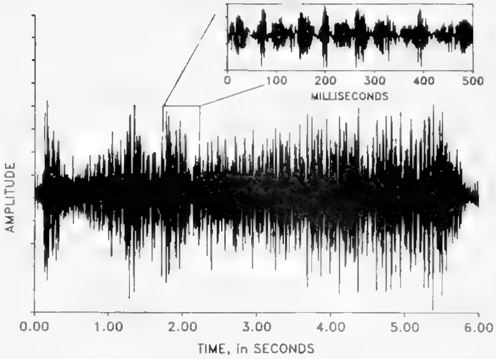

Fig. 5. Digitized oscillograph of the shortest repeated unit (SRU or volley) of the male "long call" of *Chrysoperla rufilabris*. Inset is a half-second section taken from the middle of the volley, which shows eleven individual oscillations of the abdomen (black smears). Note the absence of a clear frequency structure; the abdomen strikes the substrate and generates high-frequency noise.

were essentially identical to those from Mentone. Only one call feature showed significant differences between compared samples: Mid2 primary frequency in the Isabella and Mentone populations differed by 2 Hz. Song duration was the most variable of the measured song parameters among individuals (Tables 1 and 2).

## Discussion

The song of *Chrysoperla comanche* was found to be unique among those that have been described for eleven other species of its genus. First, it is characterized by the longest unbroken volley of any North American lacewing, averaging nearly 15 seconds in duration, but occasionally exceeding 30 to 35 seconds. The species that most nearly matches *C. comanche* in volley length is its North American sister species, *C. rufilabris*, with volleys of four to eight seconds (Henry 1980a). Another species with volleys of comparable length is the undescribed P3 sibling of *C. plorabunda*. Its volleys, produced several per SRU, can be as long as eight seconds in individuals from the Kofa Mountains of Arizona (unpublished data). The only lacewing species that seems to exceed *C. comanche* in volley length is an undescribed relative of *C. carnea* from near Ticino in the southern Alps of Europe. A volley in this species may last for more than two minutes. However, this case may not be strictly comparable, because each long bout of abdominal vibration in the Ticino form actually consists of numerous, independent short volleys repeated about eight times per second (Henry 1983a).

A second remarkable feature of the *C. comanche* call is the modulation of the primary abdominal vibration frequency by regular, intense oscillations of lower frequency. Some green lacewings that produce a series of short volleys in rapid succession approach but do not attain the condition seen in *C. comanche*. For example, a sibling species of *C. downesi* from the redwood forests of California (Founder's Grove) repeats its short volleys at nearly 10 per second (unpublished data), and two sibling species of *C. carnea* from different parts of the Alps of Switzerland may attain volley repetition rates of about eight per second (Henry 1983a,

Table 3. Principal characteristics of the songs of *Chrysoperla comanche,* normalized to 27°C and averaged for all measured volleys produced by males versus females (upper section of table) or produced by individuals from Isabella Lake versus Mentone, California (lower section). The corresponding features of the songs of *Chrysoperla rufilabris* are entered at the bottom of the table for comparison. Mean values and standard deviations are tabulated, with the number of measured individuals (column 1) or volleys (all other columns) entered parenthetically. Significant differences (between rows) at the 1% level are indicated by asterisks. N/a = not applicable.

| | Abdominal Vibration Frequency (strokes/second) | | | | Modulation Frequency (maxima/second) | | | Song Duration (seconds) |
|---|---|---|---|---|---|---|---|---|
| | Initial (A) | Mid1 (B) | Mid2 (C) | End (D) | Initial (A) | Mid (C) | End (D) | |
| All Males:<br>(N = 9) | 73.66<br>± 5.50<br>(39) | 88.06<br>± 2.94<br>(70) | 86.41<br>± 2.35<br>(71) | 80.40<br>± 5.24<br>(63) | 14.21<br>± 3.23<br>(17) | 21.19<br>± 1.21<br>(70) | 18.21<br>± 2.56<br>(43) | 16.36<br>± 5.76<br>(67) |
| All Females:<br>(N = 8) | 76.51<br>± 4.57<br>(50) | 87.54<br>± 2.14<br>(89) | 85.64<br>± 1.67<br>(89) | 78.70<br>± 3.68<br>(82) | 13.70<br>± 2.39<br>(19) | 21.14<br>± 0.82<br>(87) | 17.13<br>± 1.76<br>(74) | 13.36<br>± 4.97<br>(83) |
| All Isabella:<br>(N = 13) | 75.67<br>± 4.38<br>(61) | 88.06<br>± 2.38<br>(118) | 86.42 ***<br>± 2.04<br>(119) | 80.19<br>± 4.48<br>(106) | 13.59<br>± 2.50<br>(21) | 20.45<br>± 1.22<br>(118) | 16.47<br>± 2.37<br>(82) | 14.90<br>± 5.03<br>(112) |
| All Mentone:<br>(N = 4) | 74.37<br>± 6.57<br>(28) | 86.94<br>± 2.78<br>(41) | 84.71 ***<br>± 1.37<br>(41) | 77.41<br>± 3.87<br>(39) | 14.42<br>± 3.17<br>(15) | 20.95<br>± 0.96<br>(39) | 16.99<br>± 2.17<br>(35) | 14.13<br>± 6.83<br>(38) |
| Totals:<br>(N = 17) | 75.26<br>± 5.17<br>(89) | 87.77<br>± 2.53<br>(159) | 85.98<br>± 2.03<br>(160) | 79.44<br>± 4.49<br>(145) | 13.94<br>± 2.79<br>(36) | 21.16<br>± 1.01<br>(157) | 17.53<br>± 2.14<br>(117) | 14.70<br>± 5.53<br>(150) |
| *Chrysoperla rufilabris*:<br>(N = 10, 28 C) | n/a | n/a | n/a | n/a | —<br>—<br>— | 18.20<br>± 1.11<br>(116) | —<br>—<br>— | 5.15<br>± 1.23<br>(183) |

1985a). In contrast, *C. comanche*'s signals consist of long, continuous volleys, with no pauses in primary abdominal vibration activity between the amplitude peaks (Fig. 2). Also, the rate or frequency of modulation, about 21 Hz, is higher by a factor of two or more than in species with discrete, rapidly repeated volleys. The interaction of the primary and modulation frequencies at two temperature extremes is illustrated in Fig. 2.

The universal pattern of singing within the *carnea* group of *Chrysoperla* is the production of identical SRU's alternately by each individual of a courting pair. Whether these are single volleys or complex series of volleys, those of one partner do not overlap or acoustically interfere with those of the other. In contrast, duets in *C. comanche* are not "polite"; the female typically answers the male halfway through his one-volley call, and then both partners often sing simultaneously for several minutes before copulating. Similarly, in *C. comanche*'s closest North American relative, *C. rufilabris,* the male produces a song consisting of a single, long volley of abdominal vibration, and the receptive female also answers the male in the middle of his volley (Henry 1980a).

Other basic song features are shared between *C. comanche* and *C. rufilabris* (compare Figs. 1 and 5). In both species, the SRU is an exceptionally long volley of abdominal vibration that increases steadily in amplitude to a crescendo near its end. Neither species seems to repeat its long volleys at any regular interval: the volley, SRU, and song are all one and the same. And finally, both species modulate the intensity of their calls with very low frequency, high amplitude oscillations of the abdomen, at ap-

Table 4. $Q_{10}$ factors over the range of 20 to 30°C for each of the principal features of the songs of all individuals of *Chrysoperla comanche*. Corresponding values for *Chrysoperla plorabunda* (Henry 1983b) and for *Chrysopiella minora* (Henry and Johnson in press) are also tabulated. N/a = not applicable.

| Species | Abdominal Vibration Frequency (strokes/second) Initial (A) | Mid1 (B) | Mid2 (C) | End (D) | Modulation Frequency (maxima/second) Initial (A) | Mid (C) | End (D) | Song Duration (seconds) |
|---|---|---|---|---|---|---|---|---|
| *Chrysoperla comanche* (N = 17) | 1.19 | 1.32 | 1.30 | 1.28 | 1.18 | 1.86 | 1.67 | 1.78 |
| *Chrysoperla plorabunda* (N = 10) | 1.61 | 1.47 | 1.47 | 1.25 | n/a | n/a | n/a | 1.83 |
| *Chrysopiella minora* (N = 15) | 1.80 | 1.81 | 1.81 | 1.71 | n/a | n/a | n/a | 2.77 |

proximately the same rate: 21 Hz in *C. comanche*, and 17 Hz in *C. rufilabris*. These shared characteristics probably reflect the close phylogenetic relationship between the two species, because such traits are not found in the *carnea* group of *Chrysoperla*.

However, important differences also exist between *C. comanche* and *C. rufilabris*. First, *C. rufilabris* has sexually dimorphic calls, which were not found in *C. comanche*. Male *C. rufilabris* usually produce long volleys, but females answer with much shorter bursts of abdominal vibration and have not been found to produce anything resembling the male SRU (Fig. 5; see also fig. 1F and G in Henry 1980a). Second, the song of *C. rufilabris* is devoid of any primary frequency structure analogous to that of *C. comanche*; only lower frequency oscillations, corresponding to *C. comanche*'s modulation frequency, are apparent (Fig. 5, inset). It is possible that *C. rufilabris*, unlike other lacewings that tremulate, strikes the substrate with its abdomen, because considerable 500 Hz noise is carried on the 17 Hz amplitude peaks (Fig. 5, inset). Whatever the cause, the songs of the two species are distinctive and "sound" different from one another through headphones, despite their several shared characteristics.

Whether or not *C. comanche* and *C. rufilabris* can interbreed is unknown. The two species overlap geographically, thus providing the potential for hybridization: *C. rufilabris* occurs commonly in fields and meadows throughout most of North and Central America, including the American Southwest and California (Bram and Bickley 1963), and *C. comanche* has been collected at many sites in California, Arizona, New Mexico and Texas (Bickley and MacLeod 1956). Both species reproduce continually under long daylight conditions, suggesting prolonged overlap in their breeding seasons in areas of sympatry. Although the relevant breeding experiments remain to be done, the pronounced differences between the songs of the two sister species probably preclude successful interspecific courtship and mating.

The phylogenetic position of another common member of the *rufilabris* group, *C. harrisii*, is uncertain. It, too, sings during courtship, but its song is a peculiar, prolonged session of untidy, almost random vibrational bursts, and has not yet been characterized in detail. Its dark green color, conifer-associated habits, and unique male genitalia (Bram and Bickley 1963) make it easy to distinguish from *C. rufilabris* or *C. comanche*, and its song has not been found to exhibit any of the features shared by *C. rufilabris* and *C. comanche*. This indicates that the latter two species are more closely related to each other than either is to *C. harrisii*, and that *C. harrisii* may be the sister group of the *rufilabris-comanche* lineage. The reproductive behavior of the fourth relative of these species, *C. externa*, has not been investigated.

My studies of *C. comanche* and its relatives suggest that singing behavior has taken a different evolutionary direction in the *rufilabris* group of *Chrysoperla* than it has in the *carnea* group. It also provides evidence for separating *Chrysoperla* into two genera, to avoid the confusion of species groups. In both groups, singing is essential to courtship, and is complex in most species, perhaps because of the reinforcement of behavioral isolating "mechanisms" in genetically similar, potentially interbreeding taxa (Butlin 1987). However, polite duets between partners have developed principally in the *carnea* group, while the three members of the *rufilabris* group have acquired long, overlapping calls that may involve drumming on the substrate rather than tremulation.

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# SURFACE SCULPTURING OF THE ABDOMINAL INTEGUMENT OF MEMBRACIDAE AND OTHER AUCHENORRHYNCHA (HOMOPTERA)

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*Abstract.*—Scanning electron microscopic studies of the abdominal integument of auchenorrhynchous Homoptera indicate the presence of a variety of features including sensilla, acanthae, and microtrichia, the variability of which cannot be resolved by the dissecting microscope. Three classes of structures are recognized based on their celluar components: 1) multicellular processes (sensilla); 2) unicellular processes (acanthae); and 3) subcellular processes (microtrichia). Four kinds of sensilla were found: sensilla coeloconica, sensilla papillosa (previously undescribed), sensilla trichodea, and sensilla placodea. In a survey of 46 genera representing 12 families (Eurymelidae, Cicadellidae, Membracidae, Biturritiidae, Aetalionidae, Cercopidae, Aphrophoridae, Tibicinidae, Cixiidae, Delphacidae, Fulgoridae, and Flatidae), sensilla and non-sensory protuberances were found on the non-genital abdominal terga of members of all auchenorrhynchous superfamilies except the Fulgoroidea.

*Key Words:* Homoptera, Auchenorrhyncha, morphology, integument, surface sculpturing, sensilla

Examination of the abdominal integument of many auchenorrhynchous Homoptera by scanning electron microscopy reveals several fine-structural features of potential interest to systematists. Previously, these features, which include various types of sensilla and non-sensory protuberances, have been neglected or viewed superficially as textures in revisionary works. The objectives of this paper are to describe the common fine-structural features of integument sculpturing in the Membracidae and related groups, to propose a nomenclature for such features, and to discuss their diversity and value for hypothesizing relationships among taxa.

Harris (1979) summarized the descriptive terminology of insect integumental sculpturing, proposing the use of relative rather than absolute measures of size of the individual elements of sculpturing (e.g. punctate vs. puctulate). He further proposed the prefixing of terms for sculpturing visible only at magnifications greater than 100× with "micro-" (e.g. micropunctate). While such terminology is useful at the descriptive level, it can be misleading with regards to homology if the elements of the sculpturing have fine-structure themselves. For example, the terms "punctate" and "foveate" could refer to inornate depressions in the integument as well as sensillar pores. Therefore, some nomenclatural means for differentiating integument textures based on the fine structure of the individual elements is needed if homologies among such structures are to be taken into account.

The terminology used herein is derived as much as possible from the hypothesized functional and developmental aspects of the

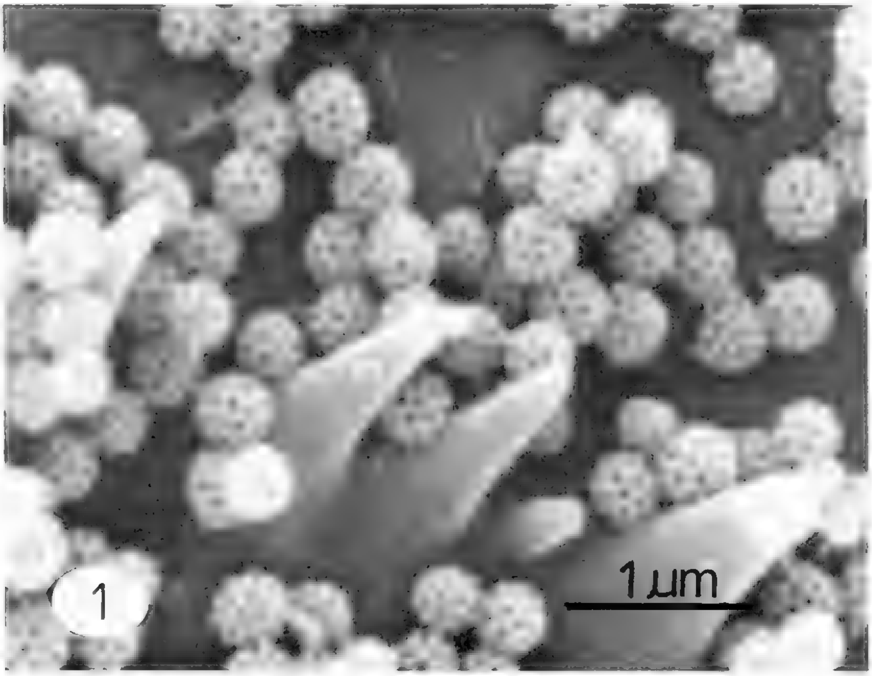


Fig. 1. Detail of abdominal integument of a cicadellid, *Draeculacephala* sp. showing microtrichia (m) and brochosomes (b).

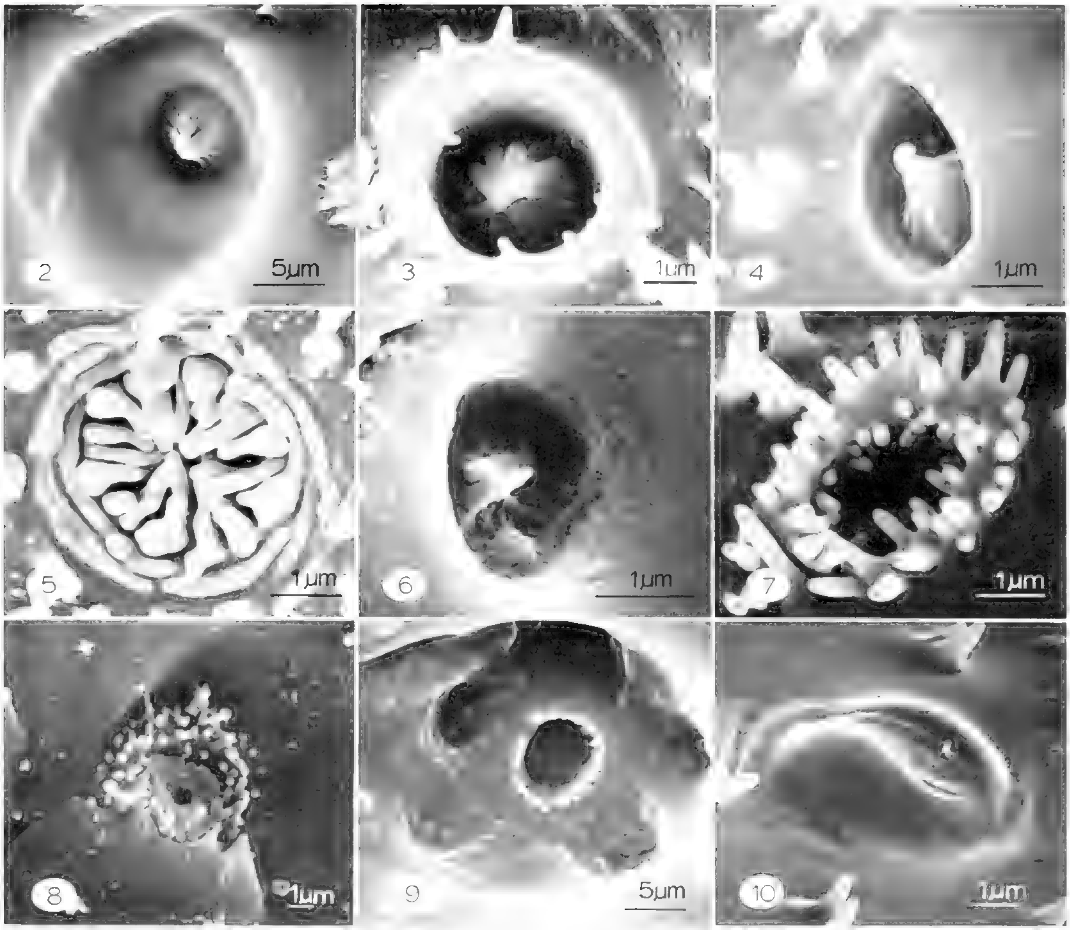
features described following Snodgrass' (1935) classification of the cuticular features of insects as updated by Richards and Richards (1979) and Zacharuk (1985).

Most detailed observations of the integumental fine-structure of Auchenorrhyncha have been restricted to the mouthparts (e.g. Backus and McLean 1983), antennae (e.g. Lewis and Marshall 1970, Bourgoin 1985), and genitalia (e.g. Restrepo-Mejia 1980). Other observations include Wood and Morris' (1974) survey of 100 species of Membracidae for the presence of articulated hairs (sensilla trichodea) on the pronotum, Wood's (1975) observations on the ultrastructure of the membracid pronotal integument, and Kitching and Filshie's (1974) study of the anal apparatus of membracid nymphs. Smith and Littau (1960) and Günthart (1977) documented the presence of minute spherical excretory granules called brochosomes covering the bodies of some leafhoppers. Presently, such observations have not been applied to systematic studies and the integument of body parts other than those mentioned above has been virtually ignored.

## MATERIALS AND METHODS

Most of the materials examined were dried museum specimens (see Table 1 for a list of taxa examined). All are deposited in the North Carolina State University Insect Collection (Department of Entomology, North Carolina State University, Raleigh). The abdomen of each was removed, glued to an aluminum stub with conductive graphite paint, coated with gold or gold/palladium in a sputter coater and observed and photographed in a JEOL T200 or Philips 505T scanning electron microscope at 10–20 kV.

To determine whether air-drying significantly distorted the fine-structural features being examined, some specimens preserved in 70% ethanol were dehydrated in a graded



Figs. 2–10. Abdominal sensilla of auchenorrhynchous Homoptera. 2–6, Sensilla coeloconica. 2, *Enchenopa* sp. 3, *Cymbomorpha amazona.* 4, *Acutalis tartarea.* 5, *Oncometopia orbona.* 6, *Philaenus* sp. 7–9, Sensilla papillosa. 7, *Cymbomorpha amazona.* 8, *Aconophora cultellata* Walker. 9, *Hypsoprora coronata.* 10, Sensillum placodeum, *Centrodontus atlas.*

series of ethanol (80, 95, and 100%), dried in a Tousimis Samdri-PVT-3B critical point drier and coated and observed as described above. In this comparison, air-drying did not appear to significantly distort the fine-structural features observed.

Many of the cicadellids examined had the integument covered with brochosomes (Fig. 1; for a description, see Smith and Littau 1960) which obscured other features of the integument. According to Günthart (1977), these can be removed by soaking the specimens in hexane, diethyl ether, or methanol. (Interestingly, the presence of brochosomes may itself be of taxonomic significance. They were found on several cicadellids, an eurymelid, and an aetalionid, but not on any of the other specimens examined—see Table 1.)

To determine the cellular basis for the individual elements of surface sculpturing, the abdomens of two specimens preserved in 70% ethanol, one pharate and one fully-sclerotized adult, were embedded in Spurr medium (Hayat 1986), sectioned with an ultramicrotome, slide mounted, stained with

Table 1. Summary of observations on the abdominal integument of selected auchenorrynchous Homoptera. (Arrangement of higher taxa follows that of Evans (1977) except where otherwise noted.)

| Taxon | Sensilla | Other Features* |
|---|---|---|
| Cicadelloidea | | |
| Eurymelidae | | |
| *Eurymela* sp. | t, c | m, b |
| Cicadellidae | | |
| *Ledra* sp. | t, c | d |
| *Evacanthus* sp. | t, c | m, b |
| *Idiocerus* sp. | | m, b |
| *Oncometopia* sp. | t, c | m |
| *Draeculacephala* sp. | t, c | m, b |
| Membracoidea | | |
| Membracidae (*sensu* Deitz 1975). | | |
| Centrotinae | | |
| Platycentrini | | |
| *Tylocentrus* sp. | t | a |
| Nessorhininae | | |
| Nessorhinini | | |
| *Goniolomus* sp. | t, c | d |
| Membracinae | | |
| Aconophorini | | |
| *Aconophora* spp. | t, c, pa | d |
| Talipedini | | |
| *Talipes appendiculata* (da Fonseca) | t, c | d |
| Hoplophorionini | | |
| *Alchisme* sp. | t, c, pa | m |
| *Hoplophorion* sp. | t, c, pa | m |
| *Ochropepla* sp. | t, c, pa | a |
| *Platycotis vittata* (Fabricius) | t, c, pa | m |
| *Potnia* sp. | t, c, pa | d |
| *Stalotypa* sp. | t, c, pa | m |
| *Umbonia crassicornis* (Amyot & Serville) | t, c, pa | m |
| Membracini | | |
| *Campylenchia latipes* (Say) | t, c | d |
| *Enchenopa* sp. | t, c | d |
| Hypsoprorini | | |
| *Hypsoprora coronata* (Fabricius) | t, pa | a |
| Centrodontini | | |
| *Centrodontus atlas* Goding | t, c, pl | m |
| Darninae | | |
| Cymbomorphini | | |
| *Cymbomorpha amazona* Stål | t, c, pa | m |
| Procyrtini | | |
| *Procyrta* sp. | t, c | m |
| Darnini | | |
| *Stictopelta* sp. | t, c | m |
| Hyphinoini | | |
| *Hyphinoe* sp. | t,c | m |
| Hemikypthini | | |
| *Proterpia* sp. | t, c | m |
| Smiliinae | | |
| Acutalini | | |
| *Acutalis tartarea* (Say) | t, c | d |
| Ceresini | | |
| *Spissistilus festinus* (Say) | t, c | m |
| *Cyphonia* sp. | t, c | m |
| Amastrini | | |
| *Vanduzeea arquata* (Say) | t, c | m |
| Smiliini | | |
| *Atymna querci* (Fitch) | t, c | m |
| *Archasia auriculata* (Fitch) | t, c | m |
| Tragopini | | |
| *Tragopa* sp. | t, c | m |
| Polyglyptini | | |
| *Entylia carinata* (Forster) | t, c, pa | m |
| *Polyrhyssa* sp. | t, c, pa | m |
| Stegaspidinae | | |
| Microcentrini | | |
| *Microcentrus caryae* (Fitch) | t, c | m |
| Heteronotinae | | |
| Heteronotini | | |
| *Heteronotus* sp. | t, c | m |
| Biturritiidae (= Lampropteridae *sensu* Evans 1948) | | |
| *Tropidaspis* sp. | t, c | d |
| *Biturritia* sp. | t, c | m |
| Aetalionidae | | |
| *Aetalion reticulatum* (Linnaeus) | t, c | d, b |
| *Darthula hardwickii* (Gray) | t | d |
| Cercopoidea | | |
| Cercopidae | | |
| *Prosapia bicincta* (Say) | — | — |
| Aphrophoridae | | |
| *Philaenus* sp. | t, c | m |
| Cicadoidea | | |
| Tibicinidae | | |
| *Tibicen* sp. | t, c, pl | m |
| Fulgoroidea | | |
| Cixiidae | | |
| *Pintalia* sp. | — | — |

Table 1. Continued.

| Taxon | Sensilla | Other Features* |
|---|---|---|
| Delphacidae | | |
| *Liburniella ornata* (Stål) | — | — |
| Fulgoridae | | |
| *Alphina glauca* (Metcalf) | — | — |
| Flatidae | | |
| *Metcalfa pruinosa* (Say) | — | — |

* KEY: a = simple acanthae; b = brochosomes; c = sensilla coeloconica; d = toothed acanthae; m = microtrichia; pa = sensilla papillosa; pl = sensilla placodea; t = sensilla trichodea; — = absence of above features.

methylene blue, and examined under a compound microscope.

## RESULTS

Sensilla and non-sensory protuberances were found on the non-genital abdominal terga of adult representatives of all the auchenorrhynchous superfamilies except Fulgoroidea (i.e. Membracoidea, Cicadelloidea, Cercopoidea, and Cicadoidea; see Table 1).

Richards and Richards (1979) classified the cuticular protuberances of insects into four major groups based on their cellular structure: 1) multicellular undifferentiated (spines); 2) multicellular differentiated (sensilla); 3) unicellular (acanthae); and 4) subcellular (microtrichia). Three of these (2, 3, and 4) were found on the abdominal integument of membracids. They are described as follows: A. Sensilla. Four kinds of sensilla-like structures were found and are named (with one addition) according to the classifications of Snodgrass (1935) and Zacharuk (1985) based on external morphology. The following designations are necessarily tentative until the functions of these features are elucidated through ultrastructural studies.

*Sensilla trichodea* are socketed, hair-like structures—setae—present in varying numbers and sizes on the abdomen of many Auchenorrhyncha (e.g. Fig. 24).

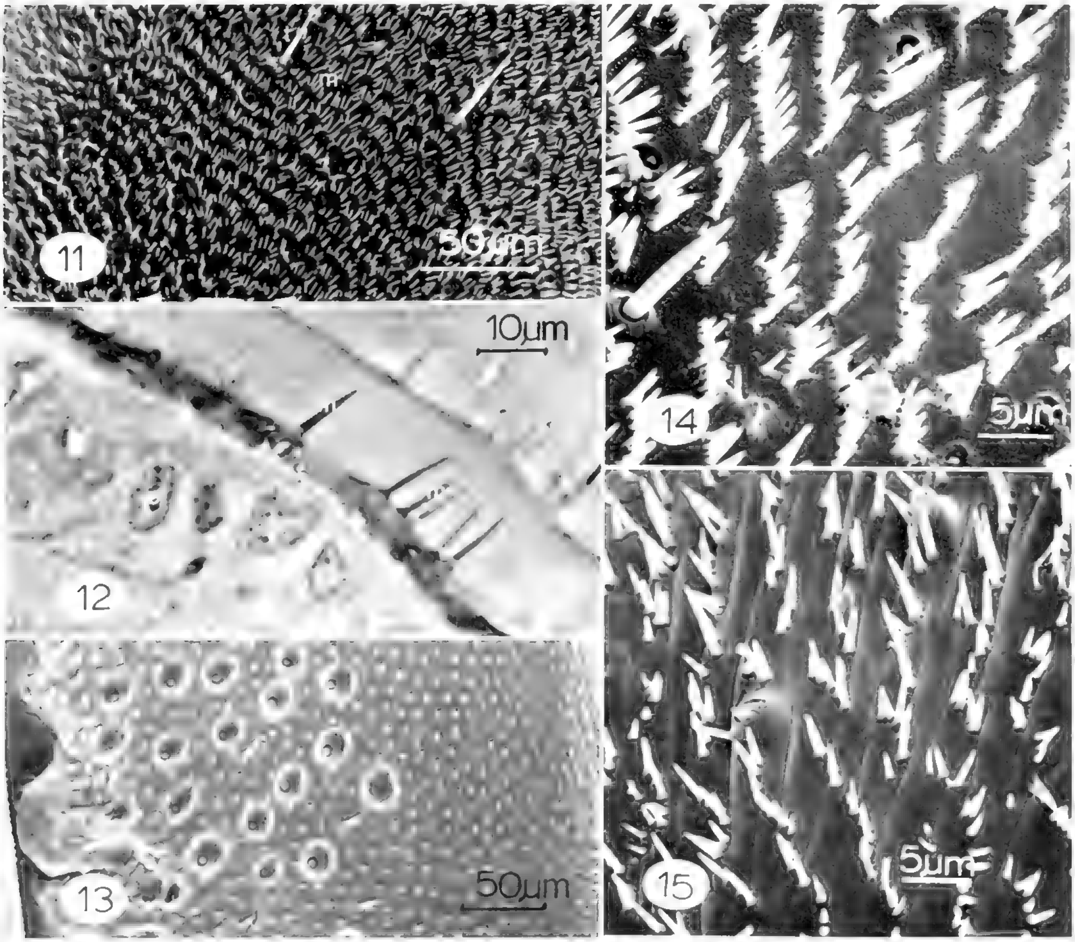
*Sensilla coeloconica* are pegs or cones set in pits approximately 1–20 μm in diameter. They vary in size, abundance, and fine-structure. When present they appear as punctations or foveae or are not visible at low magnifications (Figs. 2–6).

*Sensilla placodea* consist of a plate of sensory cuticle surrounded by a membranous ring 1–5 μm in diameter (Fig. 10). They were found on only two of the specimens examined (see Table 1) but eventually may be found to be common in some groups (e.g. Cicadoidea).

*Sensilla papillosa* are previously undescribed structures, presumed to be sensilla, consisting of groups of papillae 2–5 μm in diameter that may be associated with a pore or membrane. They are less abundant than sensilla coeloconica and are generally not visible at low magnifications (Figs. 7–9). Further study of the ultrastructure of these features is needed to determine whether they can be assigned to any of the other classes of sensilla.

B. Acanthae, microtrichia, and derivatives. The unicellular structures of Membracidae vary from single tooth-like or pectinate processes (acanthae) to divided groups of subcellular projections (microtrichia). They also vary in size and relative abundance, and give the integument a grainy to finely pubescent appearance at low magnification. Differentiation among acanthae and microtrichia presents some difficulty as it requires knowledge of the developmental origins of these structures (Richards and Richards 1979). Thin-sections of a pharate adult *Archasia auriculata* (Fitch) (Fig. 12, cf. Fig. 11) indicate that the small hair-like projections on the integument surface are relatively numerous compared to the underlying epidermal cells, demonstrating their subcellular nature. It seems likely that each of the arcuate groups of these microtrichia seen in Fig. 11 corresponds to an individual epidermal cell and is therefore derived from an acanthus (*sensu* Richards and Richards 1979).

There is often a wide range of variation in the relative amount of development of



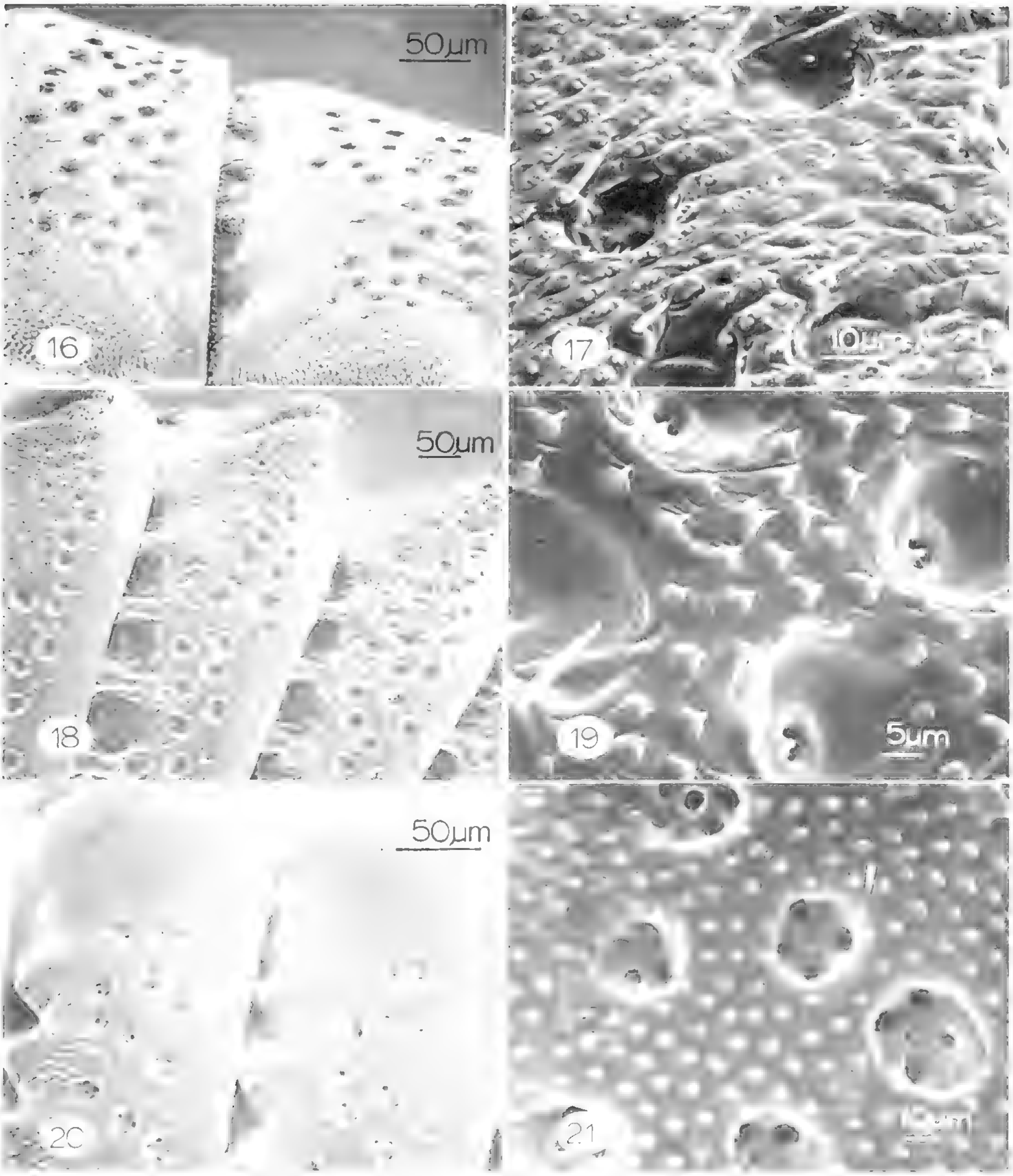
Figs. 11–15. 11–12. Cellular structure of the cuticular protuberances of a membracid, *Archasia auriculata.* 11, Distribution of microtrichia (m) and sensilla trichodea (t) on abdominal tergum IV. 12, Thin-section through a portion of abdominal tergum integument showing positions of epidermal cells (e) relative to microtrichia. 13. A portion of abdominal tergum IV of *Enchenopa* sp. (Membracidae) illustrating variation in the integument sculpturing from anterior (left) to posterior (right). 14–15. Microtextures of membracid integument. 14, Microgranulate, *Acutalis tartarea.* 15, Microrugose, *Atymna guerci.*

acanthae and microtrichia on individual specimens. The general trend in Membracidae is from maximal to minimal development from anterior to posterior ends of the individual terga (Fig. 13). Thus, when comparing taxa, it may be desirable to consider homologous sites on the specimens, or to compare only the maximal or minimal conditions of these structures.

Patterns of subcellular sculpturing, other than microtrichia, that are uniformly distributed over the integument surface may be referred to as "microtexture." Thus far, three conditions have been observed and are named according to the convention of Harris (1979): microglabrous (smooth, e.g. Fig. 27); microgranulate (grainy, Fig. 14); and microrugose (wrinkled, Fig. 15).

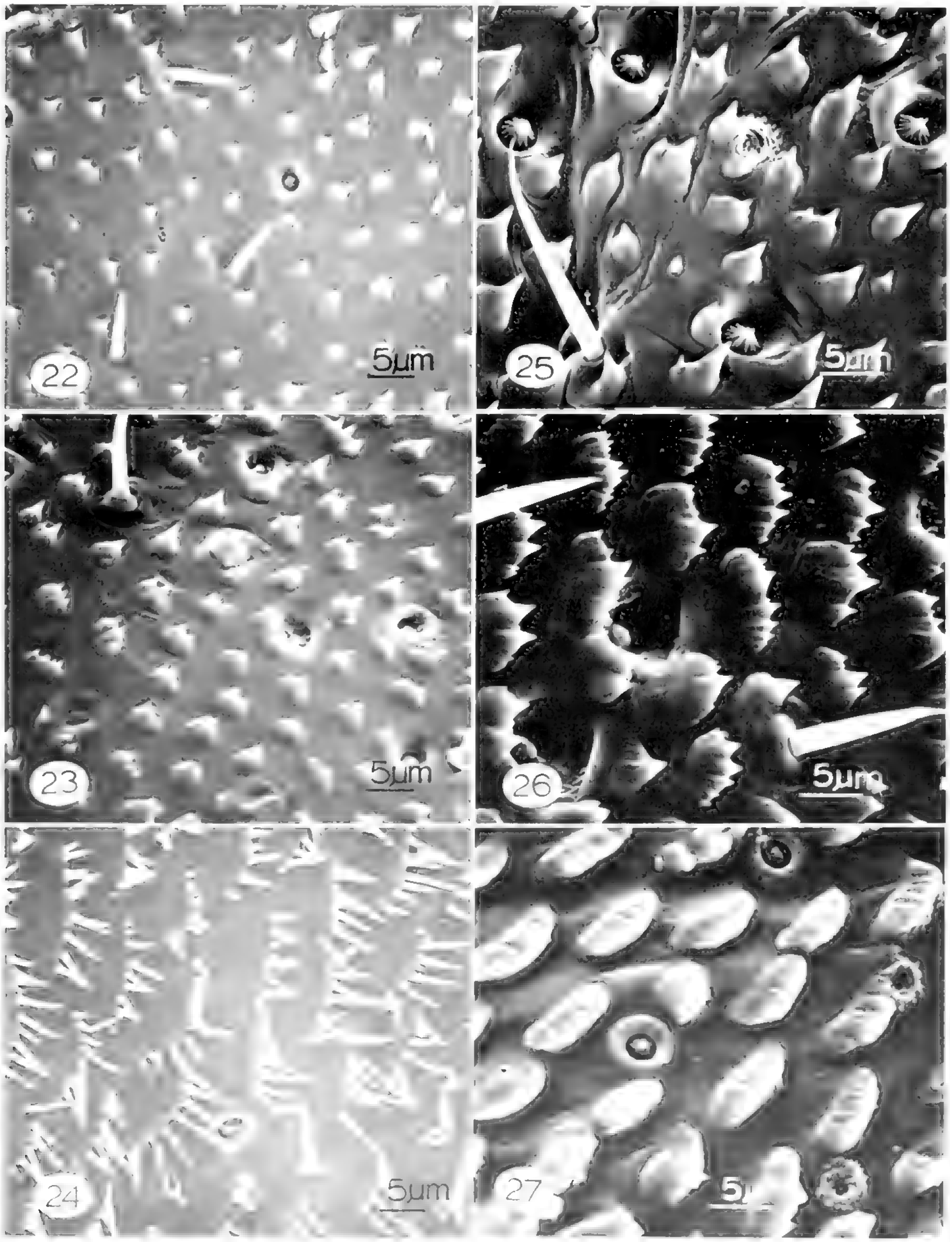
## Discussion

The observations documented here demonstrate the need to study the fine-structure



Figs. 16–21. Comparisons of foveae on the abdominal terga of three membracids (lateral views). 16–17, *Goniolomus tricorniger*. 16, Terga III and IV. 17, Detail, tergum IV. 18–19, *Talipes appendiculata*. 18, Terga III–V. 19, Detail, tergum IV. 20–21, *Hypsoprora coronata*. 20, Terga III and IV. 21, Detail, tergum III.

of integumental sculpturing if such features are to be used in systematics. Simply characterizing integument features as textures may be misleading with regards to homologies among such characters at the level of the individual fine-structural elements. Furthermore, examination of the integument fine-structure yields a wealth of morphological information that is potentially applicable to phylogenetic studies. These



Figs. 22–27. Variation of non-sensory protuberances on abdominal tergum IV in two membracid tribes. 22–24, Hoplophorionini. 22, *Ochropepla* sp. 23, *Potnia* sp. 24, *Alchisme* sp. 25–27, Aconophorini. 25, *Aconophora cultellata* Walker (t, sensillum trichodeum). 26, *Aconophora grisescens*. 27, *Aconophora* sp.

points are best illustrated with examples from the membracid taxa surveyed.

The species *Goniolomus tricorniger* Stål, *Talipes appendiculata* (da Fonseca), and *Hypsoprora coronata* (Fabricius) all have large pits on the abdominal terga bearing a superficial resemblance to one another (Figs. 16, 18, and 20). However, the fine-structure of these pits differs greatly: *G. tricorniger* (Fig. 17) has simple inornate pits, *T. appendiculata* (Fig. 19) has a single coeloconic sensillum in each pit, and *H. coronata* (Fig. 21) has a single papillose sensillum and three to five non-sensillar depressions per pit.

A trend in the evolution of subcellular protuberances is evident when representatives of the tribe Hoplophorionini (*sensu* Deitz 1975) are compared. In the genus *Ochropepla* (Fig. 22), for example, the protuberances are maximally developed as small acanthae, each bearing one or two acute projections. In the genus *Potnia* (Fig. 23), many of these acanthae are further divided into groups of three or more projections. The groups of microtrichia found in the genus *Alchisme* (Fig. 24) are each apparently homologous to a single acanthus of *Ochropepla.*

A similar trend occurs among the species of the genus *Aconophora.* The non-sensory protuberances of *Aconophora cultellata* Walker (Fig. 25) are maximally developed as single to tridentate acanthae. The acanthae of *Aconophora grisescens* (Germar) (Fig. 26) are multidentate. In a third (undescribed) species (Fig. 27), the acanthae each have several blunt crenulations, suggesting a secondary reduction of the pointed denticulae found in other species of the genus.

A more extensive survey of the integumental fine-structure of Auchenorrhyncha is needed to determine whether this previously overlooked complex of characters supports current taxonomic classifications of the group. Furthermore, elucidation of the functions of the sensilla described herein may provide valuable information concerning the evolution and ecology of the taxa in which they occur.

## ACKNOWLEDGMENTS

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91(2), 1989, pp. 153–157

# WATER AND TEMPERATURE RELATIONS OF THE PRIMITIVE XYLOPHAGOUS COCKROACH *CRYPTOCERCUS PUNCTULATUS* SCUDDER (DICTYOPTERA: CRYPTOCERCIDAE)

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*Abstract.*—Percent total body water content, cuticular permeability (CP), rate of water loss, and critical thermal maxima and minima were determined for the xylophagous cockroach *Cryptocercus punctulatus.* There was no difference between female and male *C. punctulatus* for any of the measured variables. Mean percent total body water was 75% and cuticular permeability was 44.1 $\mu$g cm$^{-2}$ h$^{-1}$ mm Hg$^{-1}$. Critical thermal temperatures were 40.3°C and −7.8°C for maxima and minima, respectively. The CP of *C. punctulatus* was similar to that of closely related blattid cockroaches and two sympatric termite species. Critical thermal temperatures were not similar to those of related taxa.

*Key Words:* Dictyoptera, *Cryptocercus punctulatus,* temperature sensitivity, water relations, desiccation

The primitive xylophagous cockroach, *Cryptocercus punctulatus* Scudder (Dictyoptera: Cryptocercidae), inhabits moist decaying hard and soft wood in the southern and northwestern United States. This species is considered an example of the close phylogenetic relationship between the cockroaches and termites (Cornwell 1968). Both groups have cellulose digesting gut protozoa and similar proventricular and genital morphology (McKittrick 1964). Within the Blattaria, *C. punctulatus* is most closely related to the Blattidae, the family that contains the pest genera *Blatta* and *Periplaneta.*

Not only do *C. punctulatus* consume wood, but they live in small social groups within wood. Colony galleries consist of networks of horizontal shafts, smaller transverse shafts, and enlarged arena-like areas (Nalepa 1984). The logs containing colonies are quite damp, containing up to 80% moisture by weight (Appel pers. comm.). These cockroaches are primarily found in their galleries, but occasionally occur in the soil and leaf litter near decaying wood. Thus, *C. punctulatus* lives in a moist environment, buffered from rapid humidity and temperature changes.

The purpose of this study was to examine aspects of the water relations and temperature tolerance of *C. punctulatus* and to compare these parameters with those of closely related cockroaches and termites.

## Materials and Methods

Specimens of *C. punctulatus* were obtained 7 March 1987 and 12 January 1988 from decaying logs in Cleburne Co., Alabama, off U.S. 431, 2.8 km SE of the Cleburne-Calhoun Co. line (G. W. Folkerts, Department of Zoology and Wildlife Science, Auburn University, pers. comm.). Adults, nymphs, and wood were returned to the laboratory for study.

Water relations experiments.—The water content, cuticular permeability (CP), and percent of total body water (% TBW) lost over time was determined gravimetrically with a digital balance (0.01 mg sensitivity) (Appel et al. 1983, Mack and Appel 1986). Percent TBW was calculated as the difference between the initial mass of live specimens and their mass after drying, divided by the initial live mass multiplied by 100. Dry mass was determined after the specimens were dried at ca. 50°C for at least three days or until two successive weighings did not differ >0.01 mg.

CP was calculated as the $\mu$g of water lost per unit surface area (cm$^2$) per unit time (h) per unit saturation deficit (mm Hg) in a desiccator chamber. Individual cockroaches were placed in uncovered 30-ml plastic cups that were put into an 11-liter desiccator jar maintained at 30 ± 0.1°C and 0–2% RH. The conditions in the desiccator were monitored with a Cole-Parmer LCD Digital Hygrometer (Model 3309-50). The hygrometer sensor was positioned at the same height in the desiccator as the specimens. Surface area was estimated for each specimen by Meeh's formula: $S = 12 \cdot M^{2/3}$, where S = surface area (cm$^2$) and M = initial mass (g) (Edney and McFarlane 1974). Mass losses were measured at 2, 4, 6, 8, 10, and 24 h, but cuticular permeability was only calculated from 2 h-data. Preliminary experiments showed no significant difference in the amount of water lost by live and HCN-killed cockroaches at 2 h. Therefore, 2-h respiratory water was less than the sensitivity of the balance (0.01 mg) and cuticular permeability could be calculated from live cockroaches without complications of respiratory mass losses. Hourly mass loss and % TBW was used to calculate % TBW lost over time.

Temperature relations experiments.—Critical thermal maxima (CTMax) and minima (CTMin) were defined as the upper or lower temperatures, respectively, that induced reversible knock-down when temperatures were rapidly increased (CTMax) or decreased (CTMin) at 1°C/min and 100% RH. Adult female and male *C. punctulatus* were used for CTMax and CTMin experiments. To determine CTMax, a 130-ml glass jar containing about 120 ml of water was sealed with a metal lid and placed into a 0.45-liter glass jar. A 5.5-cm-diameter plastic petri dish bottom containing a moistened disk of Whatman No. 2 filter paper was placed on top of the inner jar and 65 ml of water added to the space between the two jars. One cockroach was placed in the petri dish and the 0.45-liter jar was sealed with a metal lid and band. A small hole was cut in the center of the lid and a copper-constantan thermocouple (0.74-mm diameter) connected to a digital thermometer (Sensortek BAT-12) was threaded through the hole to contact the bottom of the petri dish. The thermocouple wire was attached to a 15-cm wooden applicator to ease manipulation. Body temperature and response to probing were determined by gently touching the thermocouple to the membrane between the cockroaches' meso- and metathoracic coxae. The jar-probe apparatus was placed on a hot plate that was adjusted to increase the temperature inside the apparatus at 1°C/min. Cockroaches were judged as knocked down when they lost coordination and the ability to right themselves. Recovery was assessed after 1 min at 22.8°C.

CTMin were measured in a covered 5.5-cm-diameter plastic petri dish containing a moistened disk of filter paper. A small hole was cut in the petri dish cover to allow access of the same thermocouple and probe as used for the CTMax determinations. A chill table was used as the cooling device and a constant rate of 1°C/min decline in temperature was maintained by varying the height of the petri dish above the chill table. Temperatures were measured as above, but knock down was defined as the lack of leg movement when probed. Recovery was assessed after 15 min at 22.3°C. Leg movement was used in CTMin experiments because chilled cockroaches were not always immobilized on their dorsum as with CTMax.

Statistical analysis.—A completely randomized design and a Student's *t*-test (SAS Institute 1982) were used to determine significant differences in initial mass, % TBW, and cuticular permeability between sexes. Regression was used to determine if cuticular permeability was related to initial live mass or % TBW, and how % TBW loss was related to time. Data are expressed as means ± SE. Completely randomized designs with sex as the factors were used for CTMax and CTMin. Student's *t*-tests ($P \leq 0.05$) were used to determine significance. Data are expressed as means ± SE.

## Results and Discussion

Masses of *C. punctulatus* nymphs and adults ranged from 133.9 to 876.31 mg for second instars and adults, respectively. There was no difference between the masses of adult females (829.76 ± 15.78 mg) and males (781.83 ± 17.93 mg). All stages contained about 75% TBW and there was no difference between the % TBW of adult females and males (Table 1). Edney (1977) summarized the % TBW of a variety of arthropods (45–92% TBW) and Appel et al. (1983) reported a range of 62.7 to 71.8% TBW for ten cockroach species. The more primitive blattid species generally had greater % TBW than blattellid or blaberid species. Although the significance of % TBW is unknown, the close phylogenetic relationship of *C. punctulatus* with the blattids may relate to the similarity of % TBW among these species. In addition, the % TBW of two sympatric termite species, the Formosan subterranean termite, *Coptotermes formosanus* Shiraki and the eastern subterranean termite, *Reticulitermes flavipes* Koller (both Rhinotermitidae), ranged from 62.3 to 75.9 (Sponsler and Appel unpublished data).

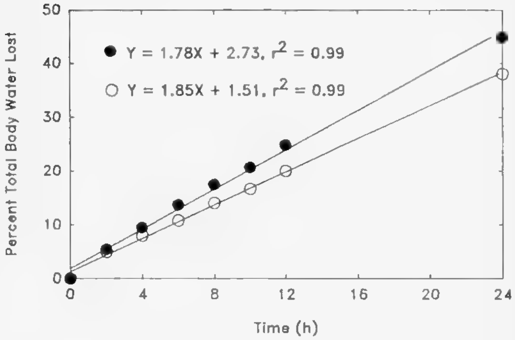

Fig. 1. Cumulative % TBW lost by female (○) and male (●) *Cryptocercus punctulatus* during desiccation at 30°C and 0–2% RH.

Percent TBW loss of female (F = 32,502.1, $P = 0.0001$) and male (F = 2340.1, $P = 0.0001$) *C. punctulatus* increased linearly with desiccation time (Fig. 1). There was a significant difference between the rate of % TBW loss (slope ±2 SE) of female and male *C. punctulatus.* This difference in rate probably resulted in the significant difference in 24-h mortality (Table 1). The greater mean mass of females, approximately 120 mg or 90 mg of water, accounts for the observed difference in desiccation-induced mortality. Linear rates of % TBW loss have been reported for cockroaches (Appel et al. 1983), termites (Sponsler and Appel unpublished data), and other insects (Mack and Appel 1986, Mack et al. 1988).

Cuticular permeability determines the rate of water loss. There was no relationship between the CP of female or male *C. punctulatus* and initial mass (F = 0.12; df = 1; $P = 0.74$ and F = 0.00; df = 1; $P = 0.99$, respectively). Similarly, there was no relationship between CP and % TBW for males (F = 1.92; df = 1; $P = 0.20$). The CP of females, however, declined linearly (F = 6.47; df = 1; $P = 0.03$) with % TBW (CP = −0.91 % TBW + 111.69; $r^2 = 0.45$). Appel et al. (1986) found that water loss of adult male *Periplaneta fuliginosa* (Serville) was

Table 1. Initial masses, percent total body water (% TBW), cuticula permeability, and mortality of female and male *C. punctulatus* [$\bar{x}$ ± SE; n = 20].

| Sex | Initial Mass (mg) | % TBW | Cuticular Permeability[a] | Mortality at 24 h |
|---|---|---|---|---|
| Female | 596.69 ± 78.20 | 74.87 ± 1.39 | 43.52 ± 1.89 | 30% |
| Male | 476.11 ± 67.70 | 76.01 ± 0.66 | 44.73 ± 3.25 | 90% |

[a] $\mu g\ cm^{-2}\ h^{-1}\ mm\ Hg^{-1}$.

negatively related to body lipid content. The negative relationship observed with female *C. punctulatus* may also be related to lipid content and factors such as age and reproductive status that affect lipid content.

There was no difference between the CP of female and male *C. punctulatus* (Table 1). The CP of *C. punctulatus* (44.1 $\mu g\ cm^{-2}\ h^{-1}\ mm\ Hg^{-1}$) was similar to those of blattid cockroaches such as *Periplaneta americana* (L.), *Periplaneta australasiae* (Fab.), *Blatta orientalis* (L.), and *Periplaneta brunnea* Burmeister with CP values of 53.7, 43.1, 43.4, and 41.7 $\mu g\ cm^{-2}\ h^{-1}\ mm\ Hg^{-1}$, respectively (Appel et al. 1983). The CPs of worker *C. formosanus* and *R. flavipes* were also similar to *C. punctulatus* (37.5 and 27.8 $\mu g\ cm^{-2}\ h^{-1}\ mm\ Hg^{-1}$, respectively) (Sponsler and Appel unpublished data). Arthropods with CPs of approximately 40 generally inhabit hygric environments such as tropical forests, moist wood, and sewers (Edney 1977).

Even though the CPs of female and male *C. punctulatus* were not different, the rates of % TBW loss (see above) were significantly different. Differences in initial mass explain this apparent discrepancy. Although both sexes had the same CP (44.1 $\mu g\ cm^{-2}\ h^{-1}\ mm\ Hg^{-1}$), there was significantly more water in females than in males. Therefore, females lose a lower percentage of their % TBW than males at any given time.

There was no difference between the critical thermal temperatures of female and male *C. punctulatus.* Critical thermal temperatures ranged from 40.9 to −8.5°C for CTMax and CTMin, respectively (Table 2). The CTMax of *C. punctulatus* is the lowest recorded for cockroaches. Previously reported cockroach CTMax ranged from 47.6 to 51.4°C (Appel et al. 1983); the CTMax of *C. punctulatus* was nearly 7.5°C lower than that of the next lowest cockroach species. Positive correlations between CTMax and habitat temperatures have been established for desert cockroaches (Cohen and Pinto 1977, Cohen and Cohen 1981), desert termites (Rust et al. 1979), and meloid beetles (Cohen and Pinto 1977). Appel et al. (1983) found that the CTMax of ten cockroach species, representing three families, could be divided into four statistically distinct groups: <48.1°C, 48.7–49.1°C, 49.3–49.5°C, and >49.6°C. There was no apparent phylogenetic relationship in the ability to tolerate high temperatures, and our results with *C. punctulatus* support this conclusion.

Few studies have reported the CTMin of insects. Sponsler and Appel (unpublished data) determined the CTMin for soldier and worker *C. formosanus* and *R. flavipes.* The mean CTMin for these termites was 13.2°C and there was no difference between stages or species. Although collected at the same time of year as these termites, the CTMin

Table 2. Critical thermal temperatures (°C) of adult *C. punctulatus* [$\bar{x}$ ± SE (minimum–maximum); n = 10].

| Sex | CTMax | CTMin |
|---|---|---|
| Female | 39.6 ± 0.28 (39.0–40.5) | −8.5 ± 0.52 (−10.0–−7.2) |
| Male | 40.9 ± 0.21 (39.7–40.9) | −7.1 ± 0.55 (−9.0–−7.1) |

of *C. punctulatus* ranged from −10.0 to −7.1°C. In addition, *C. punctulatus* remain active at −5.0 to 0°C (Appel unpublished data). Preliminary studies with *P. americana* and *B. orientalis* indicated that the CTMin of these cockroaches was much higher (ca. 10°C) than that of *C. punctulatus.*

Differences in temperature tolerance between *C. punctulatus* and sympatric termites are likely due to differences in microhabitats. *Cryptocercus punctulatus* live in moist, fallen, partially buried logs in dense forests (Seelinger and Seelinger 1983, Nalepa 1984). These logs provide a habitat insulated by moisture. With leaf littered soil as a heat-sink, these logs maintain lower than ambient temperatures (Appel unpublished data). During hot spells, evaporation cools the logs. It is also possible that the cockroaches move to preferred cooler locations within their extensive galleries. Rhinotermitid termites, however, usually maintain soil contact even when they forage on surface debris. Since most colonies are located well below the soil surface (and frost line) and are composed of thousands of metabolically active individuals, these termites are probably exposed to more constant, warm temperatures than are log inhabiting *C. punctulatus.*

Similar CPs among *C. punctulatus,* blattid cockroaches, and termites may reflect their similar high-humidity habitats or close phylogenetic relationships. The interstitial spaces in wood or soil containing >17% moisture are at saturated humidity and do not contribute to significant body water loss. Since all of these groups inhabit moist areas, it is not surprising that they all have similar CPs. Our results concur with the conclusions of Appel et al. (1983) that, in cockroaches, CP is related to habitat moisture and temperature sensitivity is related to habitat temperature.

## ACKNOWLEDGMENTS

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# FIRST NEARCTIC RECORD OF THE GENUS *NORDLANDERIA* (HYMENOPTERA: EUCOILIDAE), WITH DESCRIPTIONS OF TWO NEW SPECIES

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*Abstract.*—The genus *Nordlanderia* (Hymenoptera: Cynipoidea, Eucoilidae) is reported from the Nearctic region for the first time and two new species are described. They differ from their African counterparts by the absence of coriaceous sculpturing below the mesopleural carina and the presence of apical punctulations on the abdominal tergites. This genus is apparently restricted in distribution to arid areas of western North America and southern Africa.

*Key Words:* Distribution, southern Africa, western North America, Cynipoidea, Eucoilidae

Quinlan (1986) described the genus *Nordlanderia* and three new species from material collected in southern Africa. The genus is distinguished by the presence of triangular projections on the supraclypeal area and the anterior region of the face. This is consistent with the general tendency toward facial projections in the *Gronotoma* group of genera. This genus, previously known only from Africa, can be added to the known Nearctic fauna with the discovery of the two new species described.

## METHODS AND TERMS

Descriptions and measurements are largely based on scanning electron micrographs due to the small size of the specimens (about 1 mm total length) and the predominately reflective integument. Terms for surface sculpture follow Harris (1979) and morphological terms are after Richards (1977), Quinlan (1978) and Nordlander (1982).

Type material will be deposited in the following institutions: British Museum (Natural History); California Academy of Sciences; and the University of Idaho.

## *Nordlanderia merickeli* Miller, NEW SPECIES
Figs. 1–6

Female.—1.15 mm long. Head and thorax black, antennae dark brown, gaster dark red-brown, legs yellow-brown and wings hyaline.

*Head* subcircular in frontal view. Compound eyes normal size, weakly converging ventrally and with several very short scattered hairs between facets. Vertex smooth, with few hairs; ocelli of moderate size; posterior ocellar line longer than lateral ocellar line which is longer than ocular ocellar line. Occiput smooth, with few setiferous punctures. Face smooth, with scattered hairs below toruli and line of hairs along the inner orbital margins. Frons slightly raised. Subocular sulcus distinct, with a few poorly defined striae above and below (Fig. 1). Cheeks below sulcus and supraclypeal area strongly protruding, forming three spine-like keels (Figs. 1, 2, 4). Mandibles bidentate; inner tooth two-thirds length of outer tooth (Fig. 1). Antennae 13-segmented, clavate, with very weakly defined 8-segmented club, segment 3 equal in length to segment 4.

*Thorax* convex in lateral view. Pronotal plate not protruding; median bridge width to plate width ratio, 13:35; lateral margins parallel; foveae on lateral margins open (Fig. 3). Propleuron smooth, with scattered long hairs except on anterior margin where vestiture is both dense and long (Fig. 2). Mesoscutum smooth, with line of hairs replacing the notali. Scutellum with lateral bars smooth; scutellar plate longer than wide, with large posterior fovea and margins of plate bordered by setiferous punctures (Fig. 5); dorsal surface of scutellum above margin carinate-rugose, with circle of inwardly bent hairs around plate; scutellum below margin with widely spaced and regularly radiating striae (Fig. 6). Mesopleural carina complete; pleuron above and below suture smooth; area anterior to subalar pit depressed (Fig. 2). Metanotal plate indented posteriorly, as wide as distance between the propodeal carinae (Fig. 5). Metapleuron smooth; metapleural groove absent; pleuron depressed dorsal to obsolete ridge 1 (Fig. 2); lobe over propodeal spiracle wing-like, nearly 2× as long as wide (Fig. 6). Propodeal carinae naked, parallel anteriorly and converging towards nucha posteriorly; lateral carinal extensions continuing to near spiracle (Figs. 5, 6); propodeal surface smooth, with few hairs between the carinae, and densely pubescent laterally (Fig. 5). Legs normal and moderately pubescent.

*Gaster* with segment 1 obscured by segment 2 when viewed laterally; segment 1 forming narrow ring; tergite 2 with a basal ring of hairs, lacking any felt-like pubescence; tergite 2 the largest, occupying whole lateral surface of gaster; posterior margins of segment 2–4 punctulate; punctulations of tergite 2 faint.

*Wing* surface pubescent, with marginal ciliation of moderate length; second radial abscissa noticeably longer than first radial abscissa; radial cell closed on wing margin; submarginal vein distinct; median, discoidal and subdiscoidal veins barely discernible in some specimens.

Male.—1.18 mm long. Antennae 15-segmented, filiform; segment 3 equal in length to segment 4, very slightly curved, not swollen distally. Habitus similar to female, differing in that metapleural lobe over propodeal spiracle nearly as wide as long; medial area of propodeum densely pubescent; facial protuberances not generally as well developed.

Material examined.—U.S.A. Idaho: Nez Perce Co., Hells Gate State Park, T. D. Miller collector; 13-V-83 (1 male), 5-VI-83 (1 male, 1 female), 20-VI-83 (1 male), 15-VII-83 (1 male), 20-VII-83 (3 females), 23-VII-83 (1 male, 1 female). Washington: Asotin Co., 9 mi. W. Clarkston, T. D. Miller collector; 20-V-84 (1 male).

Types.—Holotype female, allotype male,

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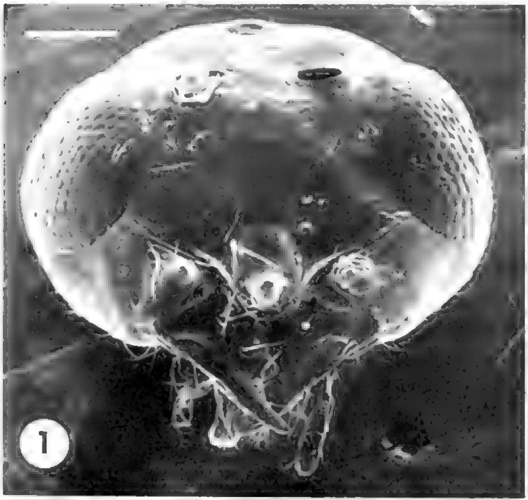
Figs. 1–6. *Nordlanderia merickeli.* 1, Frontal view of female head (scale line 75 μm). 2, Lateral view of female head and thorax (scale line 80 μm). 3, Pronotal plate of male (scale line 30 μm). 4, Dorsal view of female facial projections (scale line 30 μm). 5, Posterior view of female thorax (scale line 150 μm). 6, Lateral view of female scutellum (scale line 35 μm). (mb = median bridge; lc = lateral carinae; mpl = metapleural lobe.)

Figs. 7–12. *Nordlanderia navajoae.* 7, Frontal view of male head (scale line 75 μm). 8, Anterior view of male head and thorax (scale line 100 μm). 9, Dorsal view of female head (scale line 105 μm). 10, Pronotal plate of male (scale line 87 μm). 11, Lateral view of female thorax (scale line 135 μm). 12, Posterior view of female thorax (scale line 150 μm). (mb = median bridge; r1 = metapleural ridge 1; st = scutellar tubercle; mnp = metanotal plate.)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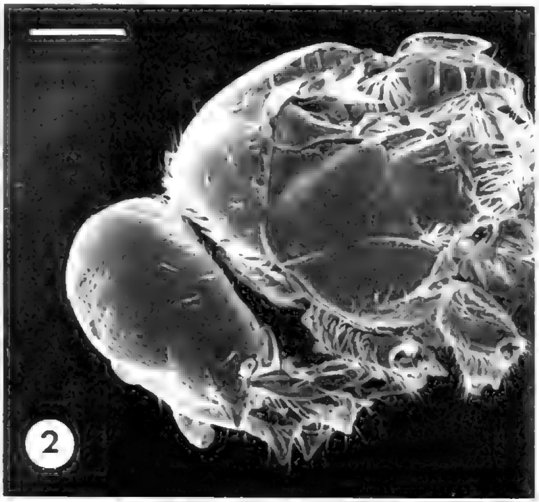
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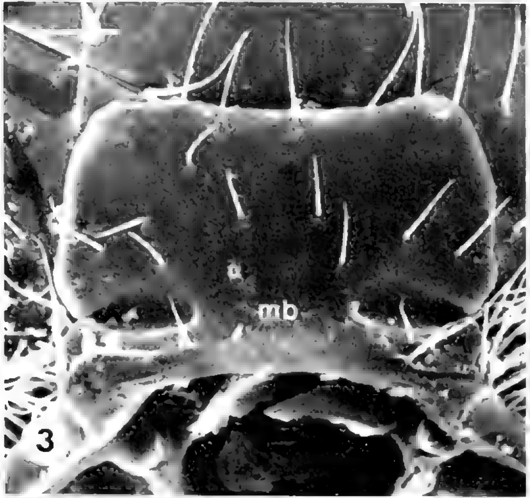
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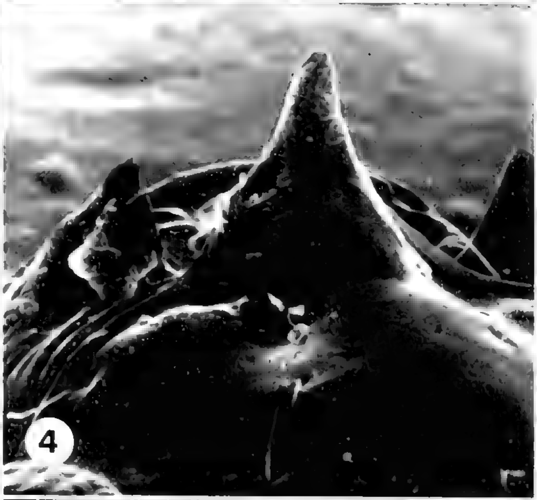
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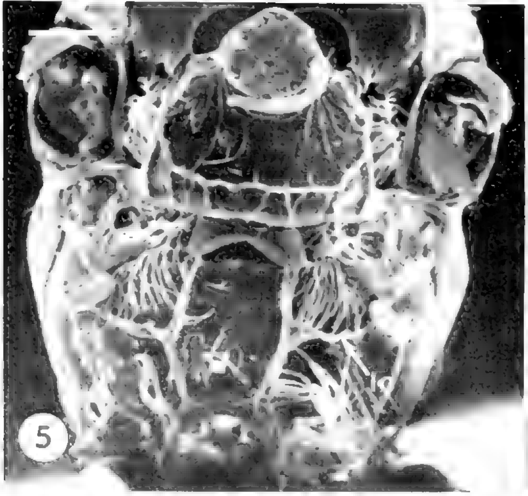
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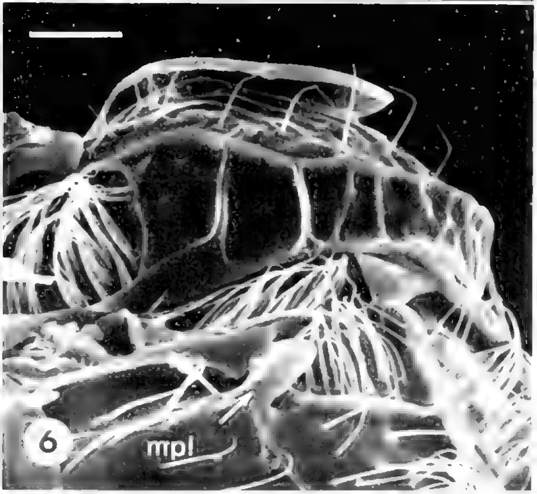
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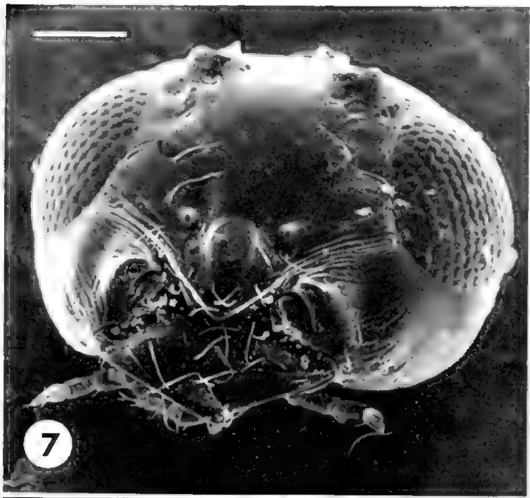
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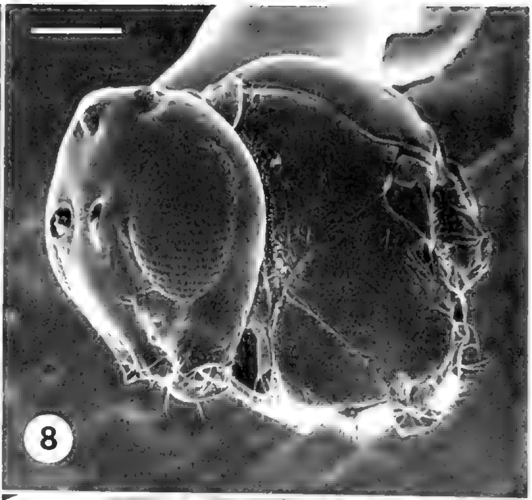
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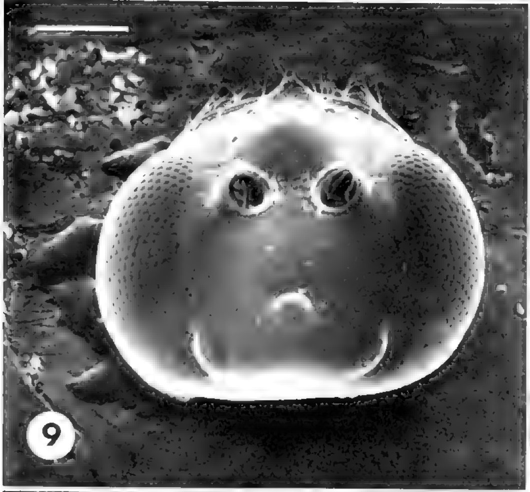
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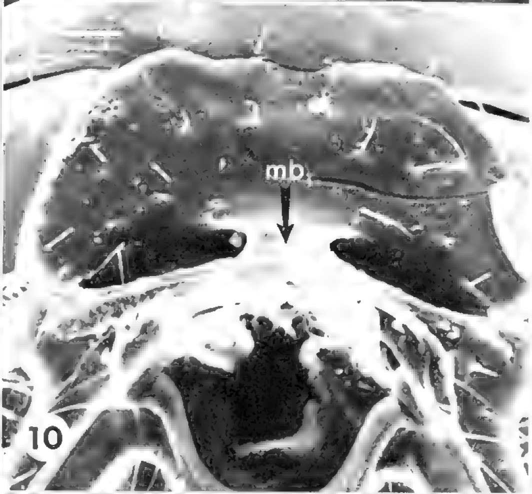
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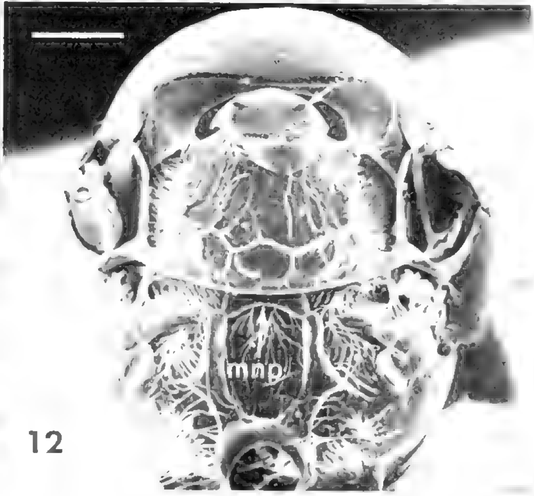
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and 2 female paratypes to be deposited in the California Academy of Sciences; 1 male and 1 female paratype to be deposited in the British Museum (Natural History); 1 male and 1 female paratype gold coated on scanning electron microscope (S.E.M.) stubs and 2 uncoated males and 1 female paratype deposited in the University of Idaho.

Etymology.—This species is named in honor of Frank W. Merickel of the University of Idaho for his valued friendship and support over the years.

Remarks.—This species is distinguished from the other new Nearctic species, *navajoae,* by the broader median bridge of the pronotal plate, size of the metanotal plate, complete lateral extensions of the propodeal carinae, lack of sculpture on the mesopleuron, ridge 1 absent on the metapleuron, and the well developed lobe over the propodeal spiracle.

### ***Nordlanderia navajoae*** **Miller**
### NEW SPECIES
Figs. 7–12

Female.—1.1 mm long. Antennae, head, thorax and gaster black, legs yellow-brown and wings hyaline.

*Head* subcircular in frontal view. Compound eyes normal size, not protruding, nearly parallel. Vertex smooth, with scattered setiferous punctures, ocelli of moderate size; posterior ocellar line longer than lateral ocellar line which is longer than ocular ocellar line (Fig. 9). Occiput smooth, with few hairs. Face smooth, with scant vestiture below toruli and irregular line of hairs along inner ocular margin. Frons slightly protruding. Subocular sulcus distinct, with well defined striae above and below, cheeks completely striate (Fig. 7). Cheeks below subocular sulcus and supraclypeal area moderately protruding to form 3 tooth-like projections (Figs. 7, 8, 9). Mandibles bidentate; inner tooth three-fourths length of outer tooth (Fig. 7). Antennae 13-segmented, clavate, with weakly defined 10-segmented club; segment 4 greater in length than segment 3.

*Thorax* convex in lateral view. Pronotal plate protruding slightly; median bridge width to plate width ratio, 9:55; lateral margins of plate curved, not parallel; foveae on lateral margins open (Fig. 10). Propleuron smooth, with scattered long hairs except anterior margin which is covered with short, dense hairs (Figs. 8, 11). Mesoscutum smooth; notali obsolete, replaced by line of hairs in some specimens. Scutellum with lateral bars smooth; scutellar plate longer than wide, with large posterior fovea and lateral margins with single puncture at midlength; anterior of lateral puncture is small, setiferous tubercle (Fig. 12), setae visible only in perfect specimens; dorsal surface of scutellum above margin areolate-rugose, with few hairs, scutellum below margin carinate-rugose (Figs. 11, 12). Mesopleural carina complete; area below suture smooth, light striations present above suture anteriorly and just below subalar pit (Figs. 8, 11). Metanotal plate indented posteriorly, not as wide as distance between the propodeal carinae (Fig. 12). Metapleuron smooth; metapleural groove absent, ridge 1 distinct (Fig. 11); lobe over propodeal spiracle short, wider than long. Propodeal carinae parallel anteriorly and converging towards nucha posteriorly; lateral carinal extensions poorly developed, not reaching spiracles (Fig. 12); propodeal surface smooth, moderately pubescent, except for naked carinae. Legs normal, moderately pubescent.

*Gaster* with segment 1 obscured by segment 2 when viewed laterally; segment 1 forming narrow ring; tergite 2 with basal ring of hairs, lacking any felt-like pubescence; tergite 2 the largest, occupying whole lateral surface of gaster; posterior margins of tergites 3 and 4 punctulate.

*Wing* surface pubescent, with short marginal ciliation; forewing broad, apically rounded; second radial abscissa slightly longer than first radial abscissa; radial cell closed on wing margin.

Male.—1.1 mm long. Antennae 15-segmented, filiform; segment 3 curved and swollen distally, greater in length than segment 4. Habitus similar to female, differing in that sculpturing of dorsal scutellar surface is less well defined.

Material examined.—U.S.A. Arizona. Apache Co., 1 mi. south of Ganado, T. D. Miller and F. W. Merickel collectors; 20-VI/ 1-VII-85 (2 females, 1 male).

Types.—Female holotype to be deposited in the California Academy of Sciences; 1 male and 1 female paratype gold coated on S.E.M. stubs deposited in the University of Idaho.

Etymology.—This species was named for the Navajo Indians upon whose tribal lands this species was discovered.

Remarks.—This species is distinguished from *merickeli* by the distinct striations on the cheeks and mesopleuron, the setiferous tubercles on the scutellar plate, metapleural ridge 1 present, the narrow median bridge of the pronotal plate, absence of lateral propodeal carinae, and the differences in antennal characters.

## DISCUSSION

The distribution of *Nordlanderia* in North America is apparently restricted to arid areas of the western United States. In addition to the two new species described in this paper several undescribed species await further study. All Nearctic *Nordlanderia* species examined so far, including the undescribed ones, differ from their African counterparts due to the absence of coriaceous sculpturing below the mesopleural carina and the presence of apical punctulations on the abdominal tergites.

## ACKNOWLEDGMENTS

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# HOST PLANTS OF *NEASPILOTA* IN CALIFORNIA (DIPTERA: TEPHRITIDAE)

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*Abstract.*—New host-plant records from California are reported for the tephritids, *Neaspilota achilleae* Johnson, *N. aenigma* Freidberg and Mathis, *N. albiseta* Freidberg and Mathis, *N. appendiculata* Freidberg and Mathis, *N. callistigma* Freidberg and Mathis, *N. stecki* Freidberg and Mathis, and *N. viridescens* Quisenberry. *Neaspilota stecki* is initially reported from California. The host plants of these tephritids are mainly in the tribe Astereae of Asteraceae, although *N. achilleae* was reared for the first time from the western United States and from capitula of *Stephanomeria virgata* Bentham in the tribe Cichoreae. Besides new records from 13 species in six genera of Astereae for *N. viridescens,* another record for this tephritid from *Lepidospartum squamatum* (Gray) Gray is the first from the tribe Senecioneae for any *Neaspilota.*

*Key Words:* Diptera, Tephritidae, host plants, *Neaspilota,* subgenus *Neorellia,* Asteraceae

Recent revision of the genus *Neaspilota* (Diptera: Tephritidae) by Freidberg and Mathis (1986) facilitated determination of specimens that I had reared from capitula of California Asteraceae (= Compositae) and enabled this report on the host-plant relations of this taxon. I hereby respond to their concern that ". . . Confirmed rearing records are especially scarce from western United States, where half of the known species of *Neaspilota* occur."

## MATERIALS AND METHODS

Host-plant information on *Neaspilota* was obtained since 1980 mainly in southern California, an ecologically diverse region that is defined and treated botanically by Munz (1974) and encompasses roughly the southern third of the State. The materials and methods used in sampling mature capitula and rearing Tephritidae from samples were described by Goeden (1985). Sweep-net collections supplemented rearings. Flies were identified with keys by Freidberg and Mathis (1986). Selected specimens were confirmed by F. L. Blanc, California Department of Food and Agriculture Sacramento, and by A. Freidberg, Tel-Aviv University, Israel. All host-plant identifications were confirmed by A. C. Sanders, Curator of the Herbarium of the University of California, Riverside. Plant names follow Munz and Keck (1959) and Munz (1974).

## RESULTS AND DISCUSSION

Freidberg and Mathis (1986) reviewed the sparse information available on the natural history and host plants of *Neaspilota.* All known species develop in flower or seed heads of Asteraceae without forming galls. I offer the following information on the host plants of *Neaspilota* species in California.

*Neaspilota achilleae* Johnson.—This species was reared from three separate samples of capitula of *Stephanomeria virgata* Bentham collected in southern San Diego County as follows: 2 ♂ and 2 ♀, SE of Barrett Junction, 8-X-1987; 7 ♂ and 6 ♀, Bratton

Valley, 20-X-1987; 2 ♂, Deerhorn Valley, 20-X-1987. This is a new host-plant genus for *N. achilleae* and the first rearing record for this fly from the western United States.

Freidberg and Mathis (1986) list four species of *Aster,* three of *Chrysopsis,* three of *Erigeron,* four of *Hieraceum,* and one species each of *Prenanthes, Sericocarpus,* and *Trilisa* as hosts of *N. achilleae* from eastern United States. I have reared other genera and species, but not this tephritid, from one to five samples each of 10 species of *Aster,* three of *Chrysopsis,* nine of *Erigeron,* and two of *Hieraceum* from California. In addition, I have not reared *N. achilleae* from one sample of *Stephanomeria cichoriacea* Gray, three samples of *Stephanomeria exigua* Nuttall, nor six samples of *Stephanomeria pauciflora* (Torrey) Nuttall. *Hieraceum, Stephanomeria,* and *Trilisa* belong to the tribe Cichorieae (= Lactuceae); *Aster, Chrysopsis,* and *Erigeron,* to the tribe Astereae. Lack of rearing records and host-plant tribal affinities suggest that the "peculiar," apparently discontinuous, eastern and western distributions of *N. achilleae* by Freidberg and Mathis (1986) may represent allopatric populations with different host-plant specificities. They also reported that specimens examined from California and Arizona were smaller on the average than their eastern counterparts, which may be added evidence of allopatry. The record for *N. achilleae* "taken . . . on *Heracleum* sp." (Umbelliferae) in Phillips (1946) probably represents adults collected from a non-host. Sweep records from Asteraceae may be poor indicators of the host-plant affinities of nonfrugivorous, nongallicolous Tephritidae (Goeden 1987, and unpublished data). The western populations of *N. achilleae* appear more stenophagous than the eastern populations, possibly monophagous, and, therefore, could have been derived from eastern ancestral stock via Cichoreae, and could be a separate species.

*Neaspilota aenigma* Freidberg and Mathis.—Only five males have previously been found in California, including the holotype and three allotypes swept in Inyo County (Freidberg and Mathis 1986). I have since reared the following specimens from capitula samples: *Acamptopappus shockleyi* Gray, 7 ♂ and 6 ♀, SE end of Kingston (Mountain) Range, NE San Bernardino Co., 27-V-1982; *Lessingia lemmonii* Gray, 1 ♀, Lockwood Valley, Los Padres Nat. Forest, Ventura Co., at ca. 1700 m elev., 31-VIII-1986; 1 ♂, Mojave River Forks, San Bernardino Nat. Forest, SW San Bernardino Co., 13-VIII-1987; *Machaeranthera tortifolia* (Gray) Cronquist and Keck, 2 ♂, along Death Valley Road, Last Chance Mountain Range, at 1130 m elev., Inyo Co., 9-VI-1987.

Freidberg and Mathis (1986) reported its host plants as *Haplopappus gooddingii* (A. Nelson) Munz and Johnston, and possibly *H. hartwegi* (Gray) Blake. I have not yet sampled *H. gooddingii* or reared *N. aenigma* from 17 other California species of *Haplopappus* sampled. *Haplopappus hartwegi* does not occur in California (Munz and Keck 1959, Munz 1974), and may be an invalid species name (A. C. Sanders in litt. 1988). Still, all four host genera mentioned above belong to the tribe Astereae (Munz and Keck 1959), and, thus, constitute a definable grouping of host Asteraceae as reported for other oligophagous Tephritidae, e.g. certain California species of *Trupanea* (Goeden 1985) and *Urophora* (Goeden 1987). Freidberg and Mathis (1986) noted that the majority of known hosts of *Neaspilota* spp. in the subgenus *Neorellia,* with which the present report is concerned, belong to the Astereae.

*Neaspilota albiseta* Freidberg and Mathis.—Freidberg and Mathis (1986) listed the host plants of this southwestern species as unknown. The following is the first host-plant rearing record for *N. albiseta*: 8 males and 2 females reared from the same sample of mature heads of *Machaeranthera tortifolia* from along Death Valley Road in the Last Chance Mountains of Inyo County in 1987 that also yielded *N. aenigma.* Freidberg and Mathis (1986) noted that some plant species are hosts to two or three species of *Neaspilota.* My rearing record confirms this co-occurrence in capitula from one local host-plant species population. Synphagy also is a common mode of resource sharing in other genera of capitula-feeding Tephritidae, e.g. *Trupanea* and *Urophora* spp. (Goeden 1985, 1987).

*Neaspilota appendiculata* Freidberg and Mathis.—Freidberg and Mathis (1986) also listed the host plants of this species as unknown. The following are the first rearing records for *N. appendiculata*: *Corethrogyne filaginifolia* (Hooker and Arnott) Nuttall, 1 ♀, N of Thomas Mountain, San Bernardino Nat. Forest, Riverside Co., 29-IX-1982, 3 ♂ and 5 ♀, Big Sandy Bluff, Sierra Nat. Forest, Fresno Co., 235000 23-VIII-1988; *Macaeranthera canescens* (Pursh) Gray, 2 ♂ and 10 ♀, Onyx Peak, San Gorgonio Mountains, San Bernardino Nat. Forest, SE San Bernardino Co., 22-V-1987. Both hosts are Astereae.

*Neaspilota brunneostigma* Doane.—*Neaspilota brunneostigma,* as revised by Freidberg and Mathis (1986), has not been found in California. Therefore, all of the host-plant records for this species listed in Wasbauer (1972) remain unconfirmed.

*Neaspilota callistigma* Freidberg and Mathis.—The only host recorded for this species is *Haplopappus venetus* (Humboldt, Bonpland, Kunth) Blake var. *vernonioides* (Nuttall) Haller (Foote and Blanc 1963, Freidberg and Mathis 1986), which I confirmed when I reared one female from capitula collected near the Stanton Ranch Airfield on Santa Cruz Island, Santa Barbara Co., 13-X-1983. This female was identified as *Neaspilota* sp. in Goeden (1986). I subsequently reared two males and 16 females from capitula of *H. venetus* collected in Marrow Valley, SE of Dulzura, San Diego Co., 20-X-1987. My other rearing records are from *H. acradenius* (Greene) Blake: 1 ♂ and 1 ♀, Coyote Wells, E of Ocotillo, 100-m elev., SW Imperial Co., 6-XI-1986; 3 ♂, Sentenac Canyon, San Diego Co., 7-X-1987; 10 ♂ and 5 ♀, Mountain Springs Pass, SE San Diego Co., 7-X-1987. I have reared other tephritid genera and species, but not *N. callistigma* from one to five samples each of 15 other species of *Haplopappus*; therefore, this tephritid may be nearly monophagous.

*Neaspilota stecki* Freidberg and Mathis.—Heretofore known only from 6 males swept in New Mexico (Freidberg and Mathis 1986). One male and 2 females were reared by me from capitula of *Acamptopappus sphaerocephalus* (Harvey and Gray) Gray collected at Snow Creek, Riverside Co., 7-V-1981. This is a new state record and the first host record for *N. stecki.*

*Neaspilota viridescens* Quisenberry.—As revised by Freidberg and Mathis (1986), *N. viridescens* is the most common and widespread species in this genus in California. Formerly reported only from *Aster spinosus* Bentham (Freidberg and Mathis 1986), this tephritid was additionally reared from capitula of: *A. eatonii* (Gray) Howell, 6 ♂ and 13 ♀, Perazo Meadow, NW of Truckee, Tahoe Nat. Forest, 2200-m elev., Plumas Nat. Forest, Plumas Co., 10-IX-1986; *A. scopulorum* Gray, 46 ♂ and 42 ♀, Cowhorn Valley, Inyo Nat. Forest, NE Inyo Co., 30-VI-1982; *Chrysothamnus teretifolius* Durand and Hilgard, 53 ♂ and 53 ♀, Mountain Springs, SW Imperial Co., 6-XI-1986; *Erigeron argentatus* Gray, 3 ♂ and 1 ♀, White Mountain, 1630-m elev., Inyo Nat. Forest, Inyo Co., 18-VI-1986; *E. divergens* Torrey and Gray, 7 ♂ and 11 ♀, Seven Oaks, along Santa Ana River, San Bernardino Nat. Forest, SW San Bernardino Co., 5-VII-1983; *Gutierrezia sarothrae* (Pursh) Britton and Rusby, 1 ♂, Mountain Springs, SW Imperial Co., 6-XI-1986; *Haplopappus cooperi* (Gray) Hall, 284 ♂ and 280 ♀, Walker Well, Walker Pass, Kern Co., 21-V-1986; *H. ericoides* (Lessing) Hooker and Arnott subsp. *blakei* C. B. Wolf, 1 ♂ and 3 ♀, Orcutt, Santa Barbara Co., 12-XI-1980; *H. laricifolius* Gray, 13 ♂ and 12 ♀, NW of Kessler Peak at S end of Ivanpah Mountains, NE San Bernardino Co., 21-X-1982; *H. linearifolius* deCandolle, 33 ♂ and 20 ♀, N Meadow Creek, Sequoia Nat. Forest, Tulare Co., 21-V-1986; *H. palmeri* Gray, 3 ♂ and 4 ♀, N of Barrett Junction, San Diego Co., 20-X-1987; *H. propinquus* Blake, 27 ♂ and 35 ♀, along Kitchen Creek, Cleveland Nat. Forest, San Diego Co., 14-X-1981; *Lepidospartum squamatum* (Gray) Gray, 11 ♂ and 10 ♀, NW of Stepladder Mountains, SE San Bernardino Co., 22-X-1982; *Machaeranthera canescens* (Pursh) Gray, 1 ♂ and 4 ♀, Keystone Canyon, Inyo Nat. Forest, Inyo Co., 1-IX-1982; *M. gracilis* (Nuttall) Gray, 2 ♂ and 2 ♀, Cedar Canyon, New York Mountains, NE San Bernardino Co., 20-IX-1983.

In addition, I confirmed the host record for *Aster spinosus* with flies reared as follows: 9 ♂ and 13 ♀, Obsidian Butte, Imperial Co., 7-XII-1983; 4 ♂, Calipatria, Imperial Co., 28-XI-1984; 17 ♂ and 28 ♀, NW of Blythe, Riverside Co., 2-XII-1987.

The hosts of *N. viridescens* include plant species from two tribes of Asteraceae: Astereae (*Aster, Chrysothamnus, Erigeron, Gutierrezia, Haplopappus, Macaeranthera*) and Senecioneae (*Lepidospartum*). Apparently, this is the first rearing record of a *Neaspilota* from the Senecioneae (Freidberg and Mathis 1986). I have confirmed *Lepidospartum squamatum* as a host as follows: 7 ♂ and 7 ♀, SE of Essex at Danby Crossroads, SE San Bernardino Co., 20-X-1982.

The coexistence in southern California of an apparently generalist feeder like *N. viridescens* with oligophagous and monophagous congeners has been shown for several generalist *Trupanea* species, including *T. jonesi* Curran, *T. nigricornis* (Coquillett), and *T. radifera* (Goeden 1985). However, another interpretation of these rearing records is that *N. viridescens,* as presently defined, is composed of several oligophagous and monophagous species not yet separable morphologically.

*Neaspilota wilsoni* Blanc and Foote.—In stating that host plants of *N. wilsoni* are unknown, Freidberg and Mathis (1986) missed my rearing record for this tephritid from *Haplopappus squarrosus* Hooker and Arnott subsp. *grindeloides* (deCandolle) Keck (Goeden 1983). They listed *Coreopsis calliosidea* deCandolle in the tribe Heliantheae as an unconfirmed, but suspected host. My rearing record from a member of the Astereae casts doubt on the validity of this unconfirmed record for this possible monophage. Also, I sampled, but was unable to obtain specimens from up to five samples of four other species of *Coreopsis* or 16 other species of *Haplopappus,* many of which yielded other Tephritidae.

## CONCLUSION

The genus *Neaspilota,* as now known in California, is composed of species with a full range of host-plant specificities, including apparently strictly monophagous *N. albiseta, N. stecki* and possibly *N. wilsoni*; nearly monophagous *N. callistigma*; oligophagous *N. aenigma* and *N. appendiculata* as well as general feeders, *N. viridescens* and possibly *N. achilleae.* Other species recorded from California (Freidberg and Mathis 1986), but as yet not reared by me, for which host data are unknown or too scant to assess, include *N. footei* Freidberg and Mathis and *N. pubescens* Freidberg and Mathis.

My host-plant records for California species of *Neaspilota* generally support Freidberg and Mathis' (1986) ideas about the monophyletic lineages of the two subgenera, *Neaspilota* sensu stricto, with hosts mostly in the tribe Vernoniaeae, and *Neorellia,* with hosts mostly in the Astereae. My records associate *N. aenigma, N. albiseta, N. appendiculata, N. callistigma, N. stecki, N. viridescens,* and *N. wilsoni* with hosts in the tribe Astereae. Hosts for *Neaspilota* (*Neorellia*) species other than Astereae, were confirmed by my rearing records from Cichoreae and Senecioneae. These departures may be evidence of active speciation in the genus *Neaspilota* involving changes in host plants (Bush 1974, 1975).

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# A NEW SPECIES OF *NEOLASIOPTERA* (DIPTERA: CECIDOMYIIDAE) FROM *BACCHARIS* (ASTERACEAE) IN SOUTHERN UNITED STATES AND THE DOMINICAN REPUBLIC

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*Abstract.*—A new species, ***Neolasioptera rostrata*** Gagné (Diptera: Cecidomyiidae), which galls flower receptacles of several species of *Baccharis* (Asteraceae), is described and illustrated. It is known from Maryland, Florida, Texas, and New Mexico in the USA, and from the Dominican Republic. A field study in Texas showed that *N. rostrata* has two generations per year and that overwintering larvae diapause from November to the following September.

*Key Words:* gall midges, *Baccharis,* saltwillow

A new species of gall midge, *Neolasioptera rostrata,* is described that forms a gall in the receptacle of male and female flowers of several species of *Baccharis* in Maryland, Florida, Texas, and New Mexico, and the Dominican Republic. The life history of *N. rostrata* was studied on saltwillow, *Baccharis halimifolia* L. (Asteraceae: Astereae), in Texas. Saltwillow is a woody, perennial, dioecious shrub (2 to 3 m ht), that grows from Texas to Florida and north to New York (Tarver et al. 1979). This shrub invades pastures, rangeland, and fallow fields (Hardin 1959), but may be toxic for cattle (Kingsbury 1964, Manley et al. 1982). It is currently being studied in Texas as a potential target for biological control (DeLoach et al. 1986).

## MATERIALS AND METHODS

Anatomical terminology in the species description follows the Manual of Nearctic Diptera (McAlpine et al. 1981). Some specimens were permanently mounted in Canada balsam on slides. The specimens used for the description have been deposited in the National Museum of Natural History (USNM), Washington, D.C.

The field study of *N. rostrata* in Texas was part of a general survey of the phytophagous insect fauna of *B. halimifolia.* Observations were made on three established plots, one to two ha each, in abandoned pastures at Waller, Waller Co., and Port Lavaca, Calhoun Co., and along three kilometers of roadside ditch at Indianola, Calhoun Co., Texas. Each plot contained 50 to 100 plants of *B. halimifolia.* Flowers were sampled at about two week intervals from September 14 to November 10, 1987. At each plot, two to four stems were removed from 10 male and 10 female plants and bagged. Sample stems grew one to two m above the ground and bore 50 to 100 flowers. In the laboratory, each field sample was divided into four groups, and 25 flowers from each group were removed without bias for dissection. The number of galled flowers and the presence of larvae, pupae, and parasites were recorded. Galls collected on November 10 at Port Lavaca were measured in cross-section at 100× with a calibrated ocular micrometer in a stereo microscope. The plots were inspected monthly from December, 1981 to February, 1988, but few flowers were collected because they did not remain on the plants.

In addition to the foregoing collections, large numbers of infested flowers of *B. halimifolia* were collected between October and December, 1986 at Conroe, Montgomery Co.; Liberty, Liberty Co.; and Monroe City, Chambers Co., Texas. Some flowers were dissected; others were held for emergence of adults. On July 10, 1986, a collection was made of infested flowers of *Baccharis neglecta* Britt. at Fort Leaton, Presidio Co., Texas.

### *Neolasioptera rostrata* Gagné,
### NEW SPECIES

Adult.—Scale color pattern: frons white; posterior surface of head and all of scutum brown; legs white ventrally, brown dorsally; leading edge of wing brown except for white spot at juncture of R5 and costa; anterior half of tergites 1–7 brown, posterior half silvery-white. Antenna with 11 flagellomeres in ♂ (n = 10) (Fig. 5), 12 in ♀ (n = 10). Mouthparts (Figs. 4, 5): labrum long-attenuate; labellum elongate, broadly rounded at apex, second segment more than 3 times as long as first; palpus 4-segmented. Thoracic vestiture: scutum with dorsocentral and lateral rows of setae, covered elsewhere with scales; anepisternum with scales on dorsal half to two-thirds; katepisternum bare; anepimeron with 9–12 setae and 0–2 scales. Wing length: ♂, 1.2–1.6 mm (n = 10); ♀, 1.4–1.6 mm (n = 10). Length R5 to remainder of wing: ♂, 0.55–0.60; ♀, 0.54–0.57.

Male abdomen (Figs. 7–10): Tergites 1–7 short, with single row of setae along entire posterior margin, covered elsewhere with scales; tergite 8 short, unsclerotized and without scales on mesal third, sclerotized and covered with scales on lateral third. Sternites 2–6 with setae inside periphery, scales elsewhere; sternites 7–8 short, with setae posteriorly only, scales elsewhere. Genitalia as in Figs. 8–10, setulae on gonostylus extending to midlength on venter.

Female abdomen (Fig. 6): Tergites 1–6 longer than in ♂, vestiture as in ♂; tergite 7 less than half width of 6, double row of setae present along posterior margin, scales present on posterior half; tergite 8 approximately twice length of tergite 7, longitudinally divided except near anterior end. Sternites 2–7 similar to 1–6 of ♂, sternite 8 slightly shorter than the preceding, its setae scattered across sclerite; tergite 6 is 0.21–0.23 length of distal half of ovipositor (n = 10).

Last instar.—Length, 1.5–1.7 mm (n = 10). Integument pebbled. Spatula (Fig. 2) anteriorly with 2 triangular lobes. Papillae: three laterals on each side of spatula, two with short setae, one without; inner pleurals without setae on prothorax, with setae on remaining segments; four terminals on anal segment (Fig. 1), each with short seta; remainder characteristic of genus but setae short.

Specimens examined.—Holotype: ♂, FLORIDA, Dodge I., Miami, emerged XI-1970 from seedheads of *Baccharis glomeruliflora,* collected XI-1970, C. E. Stegmaier, Jr. Paratypes: FLORIDA: 1 ♂, same data as holotype. MARYLAND: 6 ♂, 6 ♀

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Figs. 1–10. *Neolasioptera rostrata* (1–2, 4–10) and *N. lathami* (3). 1, Eighth and anal larval segments. 2, Spatula and associated papillae. 3–5, Heads, 3, 5 in frontal view, 4 in side view. 6, Female postabdomen. 7, Male abdominal segments 5–8. 8, Male genitalia (one gonopod shown). 9, Male genitalia, lateral view. 10, Gonostylus. Scale line for Figs. 1–5, 8, 9 = 0.10 mm; 6, 7 = 0.05 mm; 10 = 0.01 mm.

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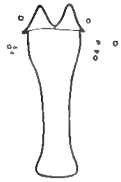

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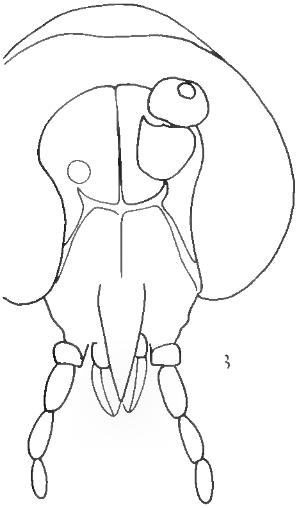

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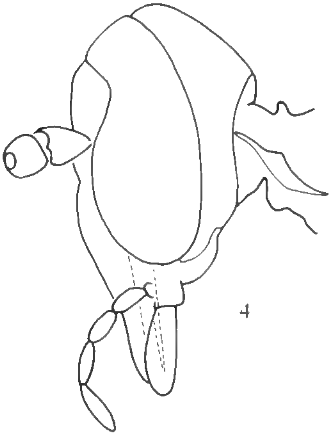

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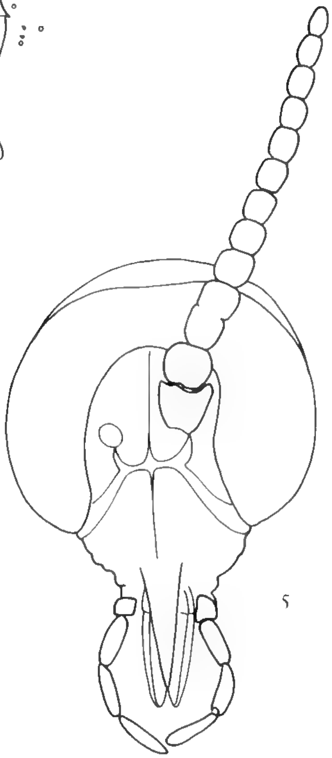

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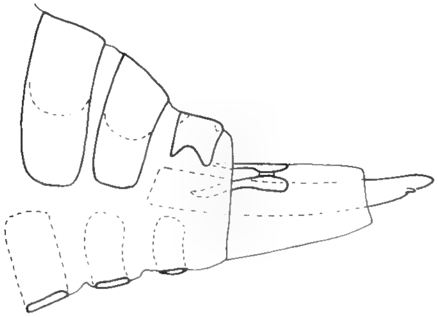

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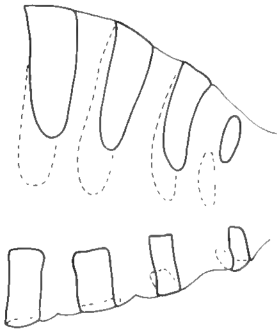

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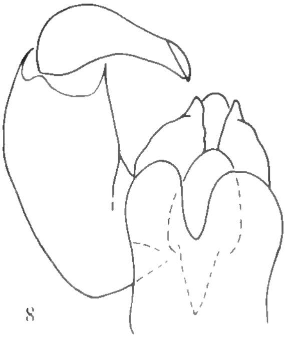

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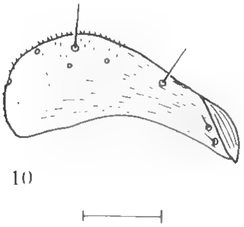

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Fig. 11. *Baccharis halimifolia.* Left, flowering branchlet and leaf, 1×. Center, flower heads, one in sagittal section to show receptacle swelling, 2×. Right, flower in sagittal section to show swollen receptacle and curled larva, 6×.

Talbot Co., emerged VIII 1985 from flower heads of *Baccharis halimifolia,* collected X-1984, V. Krischik. NEW MEXICO: 2 last-instar larvae, 4 mi. e. Loving, Eddy Co., from flower heads of *Baccharis salicina,* T. O. Robbins. TEXAS: 3 ♂, 3 ♀, Ft. Leaton St. Pk., Presidio Co., reared from flower receptacle galls on *Baccharis neglecta,* collected VII-10-1986, T. O. Robbins; 10 last-instar larvae, Indianola, Calhoun Co., from flower receptacle galls on *Baccharis halimifolia,* XI-10-1987, P. E. Boldt; 1 ♂, Liberty, Liberty Co., Hwy U.S. 90, from flower receptacle galls on *Baccharis halimifolia,* X-10-1986, P. E. Boldt; 1 ♀, Port Lavaca, Calhoun Co., from flower receptacle galls on *Baccharis halimifolia,* X-28-1987, P. E. Boldt; 1 ♂, 1 ♀, Waller, Waller Co., reared X-11-1986 from flower receptacle galls on *Baccharis halimifolia,* collected XI-1987, P. E. Boldt. DOMINICAN REPUBLIC: 5 ♂, 4 ♀, road from Constanza to San Jose de Ocoa, Prov. La Vega, emerged VII-1987 from flowers of *Baccharis myrsinites,* collected VII-17-1987, A. L. Norrbom.

Distribution.—Maryland on *Baccharis halimifolia*; Florida on *B. glomeruliflora*; Texas on *B. halimifolia* and *B. neglecta*; New Mexico on *B. salicina*; and Dominican Republic on *B. myrsinites.*

Remarks.—Adults of *N. rostrata* are similar to those of *Neolasioptera lathami* Gagné, which causes stem galls on *Baccharis* spp. from New York to Texas (Gagné 1971). The

Table 1. Mean percentage (±SD) of galls of *Neolasioptera rostrata* in male and female flowers of *Baccharis halimifolia* at three locations in Texas, 1987.

| Date | Waller | | Port Lavaca | | Indianola | |
|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female |
| September 24 | 0 | 0 | 8.0 ± 3.2 | 0 | 8.0 ± 11.2 | 0 |
| October 14 | 1.0 ± 2.0 | 0 | 5.0 ± 3.6 | 16.0 ± 8.6 | 5.0 ± 5.2 | 2.0 ± 2.4 |
| October 28 | 35.0 ± 11.4 | 30.0 ± 8.3 | 20.0 ± 7.3 | 6.0 ± 7.6 | 51.0 ± 8.4 | 12.0 ± 8.9 |
| November 10[a] | — | 11.0 ± 6.0 | — | 10.0 ± 9.4 | — | 32.0 ± 10.8 |

[a] No male flowers remaining on plant.

principal difference between adults of these species is the length of the mouthparts. The labrum and labella of *N. rostrata* are very long, reaching almost to the distal end of the outstretched third palpal segment (Figs. 4, 5). The labrum and labella of *N. lathami* are similar to those of other neolasiopteras and reach only to the distal end of the second palpal segment (Fig. 3).

Larvae of both *N. rostrata* and *N. lathami* have three lateral thoracic papillae, two with setae and one without on each side of the spatula. The inner pleural prothoracic papilla, slightly lateral to the group of lateral papillae, has no seta in *N. rostrata* (Fig. 2). Further, *N. rostrata* has four terminal papillae (Fig. 1) instead of the six found in *N. lathami.*

## Biological Notes

*Neolasioptera rostrata* produces an enlargement of the receptacle of either male or female flowers of *B. halimifolia* (Fig. 11). The gall is usually single-celled with one single larva. Two of the 227 galled flowers dissected during this work contained two larvae, each in its own cell and separated from the other by a thin wall. The full-grown larva is curled in a circle and fills the chamber. The gall in the receptacle is not apparent externally until the mature larva pushes the top of the gall into a conical shape and forms an exit hole at the apex. The hole is then covered with a silky membrane presumably produced by the larva. The larva then pupates or diapauses. Fifteen galls measured 0.69 ± 0.12 mm wide by 1.06 ± 0.20 mm high ($\bar{x}$ ± SD).

The development of the midge is closely related to the bud and flower development of its host. In Maryland, adults emerged in August and September, 1984 from flowers collected in October of the previous year. Emergence coincided with normal flowering of *B. halimifolia* in Maryland. In 1987, galls were first observed in Texas on September 24, in male flower buds at two of three locations (Table 1). Male flowers were probably attacked first because they developed sooner and were larger than female flowers. Pupae were present in both male and female flowers on October 14 at Port Lavaca. Empty galls, indicating previous adult emergence, were found on October 28, the only sample date when *N. rostrata* was present in both male and female flowers at all plots.

Of 600 senescent or blooming flowers sampled, 151 contained galls (25.2% infestation). The actual infestation rate was probably smaller because most of the senescent flowers had already dropped from the plant by that date and were uninfested. Of the 151 galls, adult midges had emerged from 37. Eight others contained pupae, nine contained small larvae, and 97 contained medium or large larvae. The presence of galls in the receptacles did not appear to affect pollen or seed production. Adult emergence in late October indicated the probability of a second generation. The small larvae present at that time were probably the progeny of the last adults of the first generation to oviposit.

On November 10, all male flowers had dropped, but some senescent female flowers remained on the shrubs. Of the 300 flowers sampled, 53 were galled (17.7% infestation) and contained medium to large quiescent larvae. Only a few empty galls or galls containing larvae were found in each of the following months through February, 1988 when sampling was discontinued.

One species of *Tetrastichus* sp. (Eulophidae: Hymenoptera) was found feeding externally on a larva collected October 28, 1987 at Port Lavaca. Another was reared from a pupa and from galls collected October 10, 1986 at Liberty. *Platygaster* sp. (Platygasteridae) was also reared from galls collected October 10, 1986, at Liberty, Texas.

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1–10; V. Krischik, A. L. Norrbom, T. O. Robbins, and C. E. Stegmaier, Jr. collected specimens of the new species; M. E. Schauff identified the Hymenoptera; and D. R. Ferguson, K. M. Harris, V. Krischik, W. A. Palmer, and R. V. Peterson reviewed a draft of the ms.

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# TWO NEW ANTS OF THE GENUS *SOLENOPSIS* (*DIPLORHOPTRUM*) FROM EASTERN TEXAS (HYMENOPTERA: FORMICIDAE)

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*Abstract.*—***Solenopsis subterranea*, n. sp.** and ***S. puncticeps*, n. sp.** are described from 10 K N of Kurten, Brazos Co., Texas, USA. *Solenopsis subterranea* also occurs in Louisiana. Both species are members of the subgenus *Diplorhoptrum* as it is presently defined. These two species have potential importance as natural enemies of founding queens of the imported fire ant, *Solenopsis invicta* Buren.

*Key Words:* Formicidae, red imported fire ant, *Solenopsis invicta* predation, biocontrol, *Diplorhoptrum*

Ants of *Solenopsis* (*Diplorhoptrum*) are difficult to identify as the workers are very small (often less that 2 mm long) and the species demonstrate considerable convergence in the worker caste (Creighton 1950). They are primarily hypogaeic or "geobionts" (Kempf 1961), and most species are seldom collected unless special techniques are used. Their nests are often found in close proximity to the nests of other ant species from which they presumably steal brood or food.

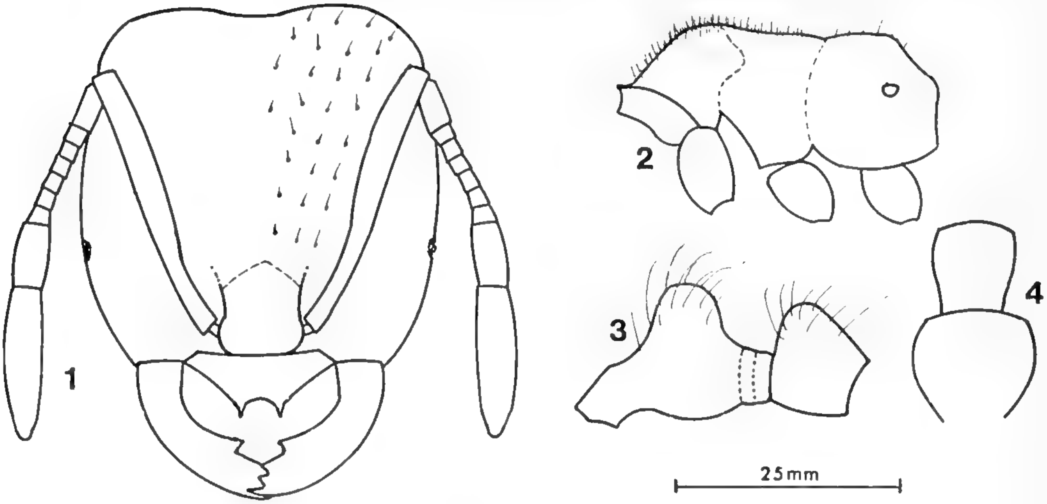
Ants of this subgenus are important as predators of founding queens of the imported fire ant, *Solenopsis invicta* Buren (Lammers 1987). There are undoubtedly many undescribed species in the subgenus, and it is in great need of revision. However, we are describing these two species at this time because of the need to place names on natural enemies which may be important in controlling populations of the imported fire ant.

## ***Solenopsis* (*Diplorhoptrum*) *subterranea***
## **MacKay and Vinson,**
## New Species

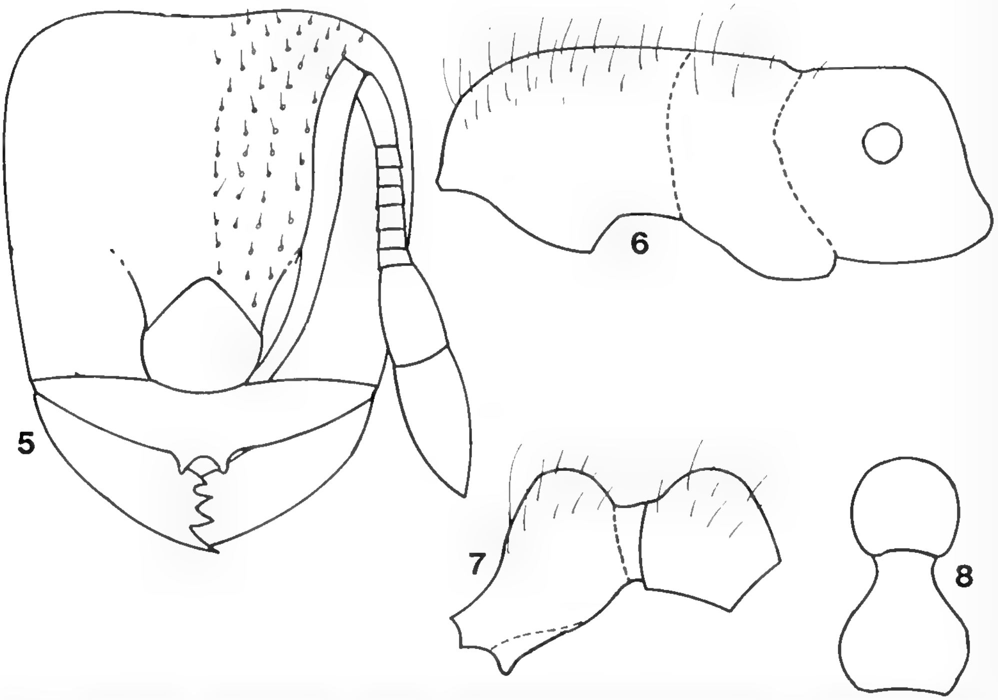
Figs. 1–4

Description (worker).—Head length (HL—anterior median border of clypeus to median occipital margin) 0.34–0.38 mm; head width (HW—maximum, at eye level) 0.24–0.25 mm; maximum eye length (EL) 0.02–0.03 mm; scape length (SL—excluding basal condyle) 0.19–0.21 mm; Weber's length (WL—anterior pronotal declivity to metasternal lobe) 0.30–0.35 mm; maximum petiolar width (PW) 0.08–0.09 mm; maximum postpetiolar width (PPW) 0.09–0.10 mm; cephalic index (CI = HW × 100/HL) 67–74; ocular index (OI = EL × 100/HL) 6–7; scape index (SI = SL × 100/HL) 52–63. Mandible with 4 well defined teeth (Fig. 1), smooth and shining with scattered punctures; clypeus with 2 well developed carinae which end in long, well developed teeth on both sides of median lobe, area between carinae depressed, smooth, shining; dorsum of head smooth, polished, with numerous scattered coarse punctures which are much greater in diameter than the hairs which arise from them (Fig. 1); occiput somewhat concave in full face view; antennal scape smooth and shining with punctures which are much smaller in diameter than those on dorsum of head, with numerous erect and suberect hairs; eye small with a total of about 3 ommatidia.

Mesosoma smooth and shining, with



Figs. 1–4 Holotype of *S. subterranea*: 1. Full face view showing representative section of punctures; 2. Lateral view of mesosoma; 3. Lateral view of petiole and postpetiole; 4. Dorsal view of petiole and postpetiole.



Figs. 5–8. Holotype of *S. puncticeps*: 5. Full face view showing representative section of punctures; 6. Lateral view of mesosoma; 7. Lateral view of petiole and postpetiole; 8. Dorsal view of petiole and postpetiole. All illustrations are drawn to same scale.

scattered punctures not much greater in diameter than the hairs which arise from them (Fig. 2); petiole and postpetiole rounded (Fig. 3), width of postpetiole greater than that of petiole (Fig. 4); gaster smooth and shining with scattered punctures not much greater in diameter than hairs which arise from them.

Entire dorsa of head and mesosoma covered by short (0.01–0.04 mm), erect and suberect hairs (Fig. 2). Light yellowish-brown with gaster and legs slightly darker, tips of mandibular teeth and eyes dark brown or black.

*Female and male:* Unknown.

Etymology.—From Latin, subter—beneath, and terra—soil, as we have found this species only below the soil surface.

Type material.—Holotype and 20 paratypes to be deposited in the Museum of Comparative Zoology, Harvard University; additional paratypes (180) to be deposited in the United States National Museum, American Museum of Natural History, California Academy of Sciences, Los Angeles County Museum of Natural History, British Museum of Natural History, Museo de Historia Natural (México), the Field Museum of Natural History, the Florida State Collection of Arthropods, Universidade de São Paulo, Museo Argentino de Ciéncias Naturales, Universidad Nacional de Colombia, the Insect Collections of Texas A&M University and Mississippi State University, and the collection of WPM.

Distribution.—Known from the type locality, 10 K N Kurten, Brazos Co. TX (eastern Texas, on N side of Ferrill Creek Rd., 3.94 K E of turnoff from Farm Road 2038 North) and southwestern Louisiana. A single worker was captured in a subterranean trap baited with a mealworm in Louisiana (not designated as a paratype). It was collected in Calcasieu Parish, Sam Houston Jones State Park on 17 Aug. 1987, collection number 9724-1. We have sampled intensively throughout the southeastern region of the United States with subterranean baits and have not collected this species in any other locality.

Biology.—Captured in subterranean pitfall traps at 10 cm depth, baited with a cooked mixture of eggs, hamburger and honey, as well as a trap baited with live mealworms. We have not captured this species on the soil surface at the type locality, despite intensive searches of the area by five different individuals.

### ***Solenopsis* (*Diplorhoptrum*) *puncticeps***
### **MacKay and Vinson,**
### NEW SPECIES

Figs. 5–8

Description (worker).—HL 0.50–0.51 mm; HW 0.48–0.49 mm; EL 0.04 mm; SL 0.35–0.36 mm; WL 0.59–0.61 mm; PW 0.14–0.15 mm; PPW 0.16–0.18 mm; CI 95; OI 7–8; SI 68–73. Mandible with 4 well defined teeth (Fig. 5), smooth and shining with scattered punctures; clypeus with 2 well defined teeth, depressed, smooth and shining between the teeth; dorsum of head smooth and shining, but with numerous large, coarse punctures (Fig. 5); occipital border slightly concave; scape smooth and shining with much smaller punctures than on the surface of head; mesosoma smooth and shining with a few scattered punctures; spiracle on propodeum very large and round in shape (Fig. 6); ventral peduncular tooth of petiole well developed, flattened and moderately pointed (Fig. 7); petiolar node not as wide as postpetiolar node (Fig. 8).

Entire body surface with erect hairs (Fig. 6): those on head short (0.02—0.05 mm) and subequal in length, those on dorsum of mesosoma longer (up to 0.8 mm) and uneven in length (Fig. 6), hairs on petiole, postpetiole and gaster similar to those on mesosoma. Color medium yellowish-brown with mandibular teeth and eyes somewhat darker.

*Female and male:* Unknown.

Etymology.—From Latin, puncta—puncture and ceps—derivation of caput for head.

Type material.—Holotype and 10 paratypes will be deposited in the Museum of Comparative Zoology, 110 paratypes will be distributed to the institutions mentioned previously.

Distribution.—Known only from the type locality, 10 K N Kurten, Brazos Co. TX (same type locality as *S. subterranea*).

Biology.—Captured in a subterranean trap baited with the cooked mixture of eggs, hamburger and honey.

Discussion.—Both of these species are members of the group of thief ants in which the dorsum of the head is covered with coarse punctures which are much larger in diameter than the hairs which arise from them (couplets 10–13 of Creighton's 1950 key to species). *Solenopsis subterranea* is apparently most closely related to, and could be confused with *S. tennesseensis* Smith (*S. longiceps* in Creighton's key). It differs in that the postpetiole is not circular as seen from above, and the head and mesosoma are covered by short erect and suberect hairs (0.01–0.04 mm long and essentially equal in length in *S. subterranea,* uneven in length with a range of 0.04–0.08 mm in *S. tennesseensis*). *Solenopsis tennesseensis* is somewhat larger (HL 0.41, HW 0.30, WL 0.44), but the CI(73), OI(7) and SI(59) are within the range of *S. subterranea.* This new species differs from *S. krockowi* Wheeler as it is much smaller (*S. krockowi*: HL 0.51–0.54, WL 0.53–0.57), and has much smaller eyes (diameter in *S. krockowi* = 0.05, OI 9–10). The clypeal teeth are very small in *S. krockowi* and the erect hairs on the head and mesosoma of *S. krockowi* are uneven in length and range from 0.03–0.13 mm. It differs from *S. salina* Wheeler in that the tooth on the anterior peduncle of the petiole of the new species is blunt and compressed (it is usually sharply pointed in *S. salina*). Hairs on the body surface are longer in *S. salina* (0.04–0.08 mm) and are greatly unequal in length.

*Solenopsis puncticeps* is distinctive in that the punctures on the dorsum of the head are very large and coarse. It could be confused with the closely related *S. pergandei* Forel which has similar punctures, but the postpetiole from above is not round in shape, as it is in *S. pergandei.* It can be distinguished from *S. krockowi* by the coarser punctures on the dorsum of the head, and the diameter of the propodeal spiracle which is about twice that of the spiracle of *S. krockowi.* It is easily separated from *S. subterranea* by the hairs on the propodeum which are much longer and unequal in length.

We suspect these species are important natural enemies of the founding queens of the imported fire ant, as are others in the subgenus *Diplorhoptrum* (Lammers, 1987). The fire ant density at the type locality of the two new species is much lower than in the surrounding area, possibly due in part to the presence of these species as well as an abundance of other species of the same subgenus.

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Dr. David Smith of the Systematic Entomology Laboratory, Agriculture Research Service, Washington, DC loaned us paratypes of *S. tennesseensis* Smith. Dr. Alex Mintzer suggested the study area, assisted in collecting ants in the area and critically read the manuscript. Dr. Awinash Bhatkar and an anonymous reviewer critically read the manuscript. Mark Strain, Shelley Stonecipher and Cecil Pinder helped search the area for colonies. The research was partially supported by Texas State Funds #2000-1925. Approved as TA-23930 by the Director of the Texas Agriculture Experiment Station, College Station.

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# BEHAVIOR AND DEVELOPMENT OF THE WASP *PTEROMBRUS RUFIVENTRIS HYALINATUS* KROMBEIN (HYMENOPTERA: TIPHIIDAE), A PARASITE OF LARVAL TIGER BEETLES (COLEOPTERA: CICINDELIDAE)

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*Abstract.*—*Pterombrus rufiventris hyalinatus* was found attacking third instar larvae of three *Cicindela* species in Arizona. Its parasitic behavior is generally similar to that described for tropical species of *Pterombrus,* but different in having a more elaborate burrow plugging behavior and one generation per year. Female wasps enter open burrows or occasionally dig into plugged burrows, sting the host larvae several times under the head or thorax, and oviposit on the second abdominal sternum. Burrows are closed with a primary plug of compacted soil immediately above the larvae and a secondary plug loosely packing the remainder of the burrow. Mean development time is 2.93 days for the egg stage and 8.70 days for larvae. When mature, wasp larvae detach from the host, spin a cocoon in the larval burrow, and emerge the following July with the onset of the "monsoon" rains.

*Key Words:* *Cicindela,* larvae, parasite, parasitic behavior, *Pterombrus,* tiger beetle, Tiphiidae, wasp

Two genera of tiphiid wasps of the subfamily Methochinae, *Methocha* and *Pterombrus,* are parasites of tiger beetle larvae. Some of the natural history and behavior of several species of *Methocha* has been described (Adlerz 1906, Williams 1916, 1919, Iwata 1934, 1936, Burdick and Wasbauer 1959, Wilson and Farish 1973). *Pterombrus* is primarily tropical in distribution and the limited knowledge about it comes from studies of *P. cicindelicidus* and *P. iheringi* in Brazil (Williams 1928) and *P. piceus* in Costa Rica (Palmer 1976). These studies included field observations and notes of parasitic behavior and development times.

*Pterombrus rufiventris* is the only known United States species of the genus. Krombein (1949) distinguished two subspecies, *P. r. rufiventris* from eastern Texas, Louisiana, North Carolina, and Virginia, and *P. r. hyalinatus* from western Texas, Arizona, and California. Nothing has been published on the biology of this species. During ecological studies of tiger beetles in southeastern Arizona, one of us (CBK) discovered *P. r. hyalinatus* parasitizing larvae of *Cicindela obsoleta, C. pulchra,* and *C. marutha.* Because of its possible importance in limiting these tiger beetle populations, field and laboratory studies of this wasp were initiated. We present here observations on parasitic behavior and development. Other studies present rates of parasitism of *Cicindela* species (Knisley 1987, Knisley and Juliano, 1988) and factors that influence rates of parasitism (Knisley, in prep.).

## METHODS

Field studies.—Field studies were done in the Sulphur Springs Valley, near Willcox, Cochise Co., AZ, during July and August from 1983–87. Eight sites representing four habitat types (playa, saltbush flat, grassland, sand ridge), each with one or more species of adult or larval *Cicindela* (Knisley 1987) were checked for wasps one to two times per week. During these checks all *Pterombrus* were counted to determine relative abundance and seasonal activity. Wasp behavior was observed and recorded.

Laboratory studies.—The behavior of *Pterombrus* was studied under laboratory conditions of summer photoperiod (13L: 11D) at 24–28°C in an observation chamber. The chamber was made from a transparent plastic "shoe" box (17 × 32 × 9 cm) and supported by 20 cm wooden legs placed under each corner. An acrylic tube (2.5 × 18 cm) filled with soil and containing an active third instar of *C. pulchra* (Knisley and Pearson 1984) was inserted through a hole in the bottom of the box so that the top of the tube was flush with the surface of a 5–6 cm layer of soil in the box. The top of the tube was wrapped with tape to ensure a tight fit of the tube into the hole. For clear observation of wasp behavior, only tubes in which the larva had dug a burrow along the side wall of the tube were used for the trials. To begin an observation trial a female wasp was placed into the covered plastic box. We observed the complete sequence of parasitic behavior for three wasps and partial sequences for three others.

Development time of *Pterombrus* was determined from host preference studies (Knisley, in prep.) in trials in which a tiger beetle larva in a rearing tube was confined with a wasp. Each parasitized larva was carefully dug from the tubes and transferred onto a disc of moistened paper towel in a plastic petri dish (10 cm dia). Developmental progress and body length of larval stages were recorded daily.

## RESULTS AND DISCUSSION

Field studies.—Distribution and behavior of wasps in the field were based on over 70 sightings of adult wasps. Only four males were observed and all were flying near females and appeared to be attempting to mate. No mating was seen. Adult wasps were found at six sites. Only one wasp was observed each at two of these sites, a ditch edge and a pond edge. No wasps were observed in the playa or playa edge habitats. Wasps were relatively common (two to five observed during each survey) at two sand ridge sites where there were large populations (over 500) of *C. marutha* larvae and at a nearby (400 m) saltbush flat where there were several hundred *C. pulchra*. *Pterombrus* was also common at a higher elevation grassland site near Chiricahua National Monument which had a population of over 300 *C. obsoleta* larvae.

Adult wasps were first observed at field sites within one or two days of the first significant July rainfall (>8–10 mm). The actual dates of first sightings were July 6 in 1986, July 10 in 1985 and July 16 in 1987. Wasp emergence may be triggered by the onset of the summer "monsoon" rains, as is tiger beetle adult emergence and larval activity. Numbers of wasp sightings decreased from July through late August at all sites, but the pattern of abundance at the grassland site was about two weeks later than at the other sites. In the field, we observed *P. r. hyalinatus* parasitizing only third instars of *C. pulchra, C. obsoleta,* and *C. marutha,* but in the laboratory some second instars of these species were attacked. Palmer (1976) found that *P. piceus* parasitizes primarily second instars of *Pseudoxychila tarsalis* Bates.

Searching behavior.—We observed the searching behavior of 15 wasps in the field. Female wasps walked rapidly over the ground, frequently turning and darting, in what appears to be a random pattern. The wasps stopped to examine or probe with their antennae holes, cracks or surface depressions. Often they passed within several centimeters of active larval burrows then moved away. Wasps initiated an attack only when they came in contact with the burrow edge. *Pterombrus piceus* searches in a similar manner and seems to prefer to attack larvae that move down the burrow when they approach (Palmer 1976).

We observed four instances of wasps digging out plugged burrows of third instar *C. marutha,* a species which typically plugs its burrows during most of the day (Knisley 1987). In each case, the wasp used its mandibles to grasp bits of sand from the plugged area, moved back 4 to 6 centimeters and dropped the sand, eventually forming a small arc or circle of sand around the burrow mouth. Removal of the 2 to 4 cm plug took 19 to 33 minutes, after which the wasp entered the burrow to attack the larva. *Methocha* (Padgen 1926) and *P. iheringi* (Williams 1928) have also been observed digging out plugged burrows. In addition, *Methocha* reportedly digs in soil where tiger beetle larvae had previously occurred (Williams 1919). These observations suggest that wasps may detect the odor of host larvae or their burrows once they come in close proximity to them. In the laboratory chambers, *Pterombrus* initiated attacks on larvae in 4 to 38 minutes ($\bar{x} = 16.2$). In the field, wasps were observed to search for 15–30 minutes without finding a larva.

*Pterombrus* did not seem to fly when searching for burrows, and seldom flew unless disturbed. Short flights (7–20 m), observed when wasps searched unsuccessfully in an area for 15 to 20 minutes, could indicate dispersal to new areas of potential larval habitat.

Attack, stinging and oviposition.—Attacks of host larvae in the laboratory were initiated by female *P. r. hyalinatus* moving quickly into the burrow head first, causing the larva to retreat. The wasp continued down the burrow until her head touched the larva's head. Sometimes the wasp used its mandibles to grasp the head of the larva before quickly curving her abdomen forward and stinging the larva under the head or thorax. This caused the larva to move further down the burrow. The wasp remained inactive for 2–5 minutes, then cautiously approached the larva and probed the larva's head with its antenna. In two of the trials with large third instars of *C. obsoleta,* the larvae responded with slight movement and were again stung once or twice.

The wasp used one or more of three methods to slightly raise the larva in the burrow: grasping the larva's head with its mandibles and pulling from above, pushing up on the caudal portion of the larva's abdomen, or grasping the larva's forelegs with its mandibles and pushing while positioned beside the larva. These movements often wedged the larva's cephalothoracic shield in the burrow. In two cases another sting was then applied to the larva's venter. We never observed larvae flipping out of the burrow. This may be a defense reaction of the larva and is reported in studies of *Pterombrus* (Palmer 1976) and *Methocha* (Mury Meyer 1983). We also did not observe wasps being seized by tiger beetle larvae. *Methocha* has been observed to allow the larva to seize it with its mandibles before quickly stinging the larva. Palmer (1976) reported one instance of this behavior in *P. piceus.*

After positioning the larva or sometimes after oviposition the wasp used the tip of its abdomen to pack the bottom of the burrow. *Pterombrus iheringi* shows similar packing behavior after using its mandibles to loosen the soil (Williams 1928). We observed one wasp grasp at the larva's second abdominal sternum. The wasp may have been chewing, feeding or preparing an oviposition site. Burdick and Wasbauer (1959) reported that *M. californica* commonly feeds on fluids exuding from sting punctures and suggested that this may provide nutrients that are necessary for successful oviposition.

To oviposit, the wasp positioned itself venter to venter with the larva, moved forward using the tip of its abdomen to sweep back and forth over the larva's abdominal sternites, then stopped and deposited an egg on the midline of the second abdominal sternum. In two cases the wasp next stung the beetle larva one or more times near the egg. These stings or the chewings near the oviposition site may prepare an access for the newly hatched wasp larva to enter the host to feed.

The number of stings given the beetle larva by both *Pterombrus* and *Methocha* is variable. Any movement by the larva seems to be sufficient to trigger a stinging response in *Methocha* (Burdick and Wasbauer 1959). Our observations suggested this may be true for *Pterombrus*. Stings also seemed to be given after certain behavioral events, such as positioning the larva and oviposition. Host larvae were apparently completely paralyzed by the stings because they did not move in their burrows, and exhibited only slight movement when probed. The effect of the stings of *Methocha* species has been correlated with the site of oviposition. Host larvae stung by species that oviposit on the host's abdomen are permanently paralyzed by the host; host larvae stung by species that oviposit on the venter of the metathorax recover and move actively in their burrows (Williams 1919, Iwata 1936).

Burrow preparation and plugging.—After oviposition the wasp moved above the larva and constructed two plugs, a compact primary plug immediately above the larva and a loosely packed secondary plug which filled the rest of the burrow. To form the primary plug, the wasp positioned itself 2–4 cm above the paralyzed larva, curved its abdomen forward across the burrow shaft and used its mandibles to dislodge soil particles from the sides of the burrow. Soil fell onto the underside of the abdomen, was compacted there with the hind legs and then pressed onto the sides of the burrow with the abdomen. As the wasp moved in a circle, the activity eventually formed a circular shelf of soil. To complete the primary plug, the wasp moved to near the top of the burrow, used its mandibles to dislodge soil onto the shelf, then moved down and appeared to use its hind legs to cover the hole in the shelf left by its abdomen. The primary plug was 1.5–3.0 cm thick and required 7–15 minutes to complete.

Next, the wasp left the burrow and searched the area within 10–20 cm of the burrow entrance for bits of soil, stones, twigs and other materials for the secondary plug. The wasp carried each piece in its mandibles and usually dropped it into the burrow from without. Filling of the burrow and completion of the secondary plug required from 21 to over 140 trips and 13–41 minutes ($\bar{x}$ = 18, n = 12). Types of materials available around the burrow and depth of the burrow seemed to account for the variation in number of trips and time. For example, filling of burrows at the saltbush flat site required more time because plugging materials were scarce. At a sand ridge site and in two laboratory chambers where the soil was nearly pure sand, wasps formed most of the secondary plug by pushing sand into the burrow with the hind legs. Plugging was then completed by filling in with larger materials. In general, wasps seemed to be more selective of materials during the final phase of burrow plugging.

The surface appearance of the plugged burrows was distinctive at each of the sites. The secondary plugs at the grassland site consisted of small pebbles. Those at the saltbush flat had small twigs, bits of plant material or flakes of soil. Sand ridge burrows were filled with sand and often eroded around the edge. *Methocha* plugged burrows with a variety of materials (Bouwman 1909, Champion and Champion 1914), possibly selecting them on the basis of availability and ease of transport (Burdick and Wasbauer 1959). Complete closure of the

Table 1. Duration and size (length in mm) of developmental stages of *P. r. hyalinatus* reared in the laboratory at 24–28°C.

| | N | Mean | SD | Range |
|---|---|---|---|---|
| Egg length (mm) | 15 | 2.39 | 0.14 | 2.10–2.52 |
| Duration egg stage (days) | 14 | 2.93 | 0.59 | 2.30–3.90 |
| Larval length (mm) on day after hatch: | 9 | 2.86 | 0.38 | 2.52–3.57 |
| 2 | 8 | 3.61 | 0.34 | 2.45–4.34 |
| 3 | 9 | 4.70 | 0.58 | 3.90–6.09 |
| 4 | 7 | 6.56 | 0.95 | 5.18–7.42 |
| 5 | 11 | 5.76 | 1.01 | 4.64–6.24 |
| 6 | 6 | 9.12 | 1.35 | 5.76–10.88 |
| 7 | 8 | 9.04 | 2.26 | 8.00–11.20 |
| 8 | 8 | 14.88 | 1.29 | 13.12–16.16 |
| Duration of larval stage (to detachment from host) (days) | 15 | 8.70 | 1.35 | 7.80–10.50 |
| Total development time (days) | 25 | 12.33 | 2.65 | 10.70–15.30 |

burrow may be necessary to protect the developing wasp against natural enemies. We noticed that several incompletely plugged burrows were dug into by ants and the host larvae were eaten.

Plugging burrows with two plugs by *P. r. hyalinatus* involves more elaborate behavior than the single plugging by other species of *Pterombrus.* This may be an adaptation to the dry environment of *P. r. hyalinatus* where infrequent rains are less likely to naturally close the burrow. The single plug constructed by *P. piceus* (Palmer 1976) resembles the secondary plug described here. The single plug of *P. iheringi* (Williams 1928) is similar to the primary plug of *P. r. hyalinatus.* Observations of *Methocha* indicate plugging involves a complete filling of the burrow (Alderz 1906, Bouwman 1909, Burdick and Wasbauer 1959).

Development.—Upon hatching the wasp larva typically remained at the site of oviposition on the second abdominal sternum and began extracting the liquid contents of the host larva. Growth was rapid with larvae increasing by about 1–1.5 mm per day, from a mean length of 2.8 mm at hatching to 14.8 mm when fully grown after eight days. Detachment from the host and initiation of cocoon spinning began when the host was completely consumed and shriveled. The cephalothoracic shield of the host was typically attached to the top of the pupal cocoon and apparently served as a starting point for cocoon spinning. The pupal cocoon was similar to *P. cicindelidicus* (Williams 1928). Adult *Pterombrus* collected at the saltbush flat and grassland sites which had larger host tiger beetle larvae (*C. pulchra* and *C. obsoleta,* respectively) had a mean length of 13.5 mm and those collected at the sand ridge sites with the smaller *C. marutha* had a mean length of 10.5 mm. In laboratory host preference studies pupal size was highly correlated with host larva size (Knisley, in prep.).

Mean time from oviposition to completion of the pupal cocoon was 13.2 days (SD = 1.6, range 10.2–17.3) (Table 1). Mean duration of stages was 2.93 days for the egg, 8.70 days for the larva, and 1.60 days from larval detachment to completion of the cocoon. Larval development is about 12 days for *P. piceus* (Palmer 1976) and 10–12 days for several *Methocha* species.

The behavior we observed for *P. r. hyalinatus* was similar in most aspects to that of other species of the genus. The more elaborate plugging behavior and the one generation per year may be adaptations to a different environment. Our observations also indicate similarity between the behavior of *Pterombrus* and *Methocha* and suggest that these behaviors have evolved in response to the highly specialized life of larval tiger beetles. The apparent consistent difference between these genera is the initial attack behavior in which *Methocha* allows itself to be seized by the larva. Studies on searching, host selection, and abundance of these two genera of parasitic wasps could provide important additional information for determining how they limit tiger beetle populations.

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Mark R. Carter, David R. Beatty, and Frank W. Ellis assisted in the field work. Karl V. Krombein identified *P. r. hyalinatus.* This research was supported in part by grants from the National Science Foundation (DEB8119256 and BSR8415949).

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# DESCRIPTION OF THE PREDACEOUS LARVA OF *PSEUDOGAURAX SIGNATUS* (LOEW) (DIPTERA: CHLOROPIDAE)

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*Abstract.*—A description of the predaceous larva of *Pseudogaurax signatus* (Loew) (Diptera: Chloropidae) includes an illustration of the cephalopharyngeal skeleton, spinule pattern and posterior spiracles and scanning electron micrographs of the cuticular armature, facial mask and the anterior and posterior spiracles.

*Key Words:* larval morphology, ultrastructure, spider-parasite

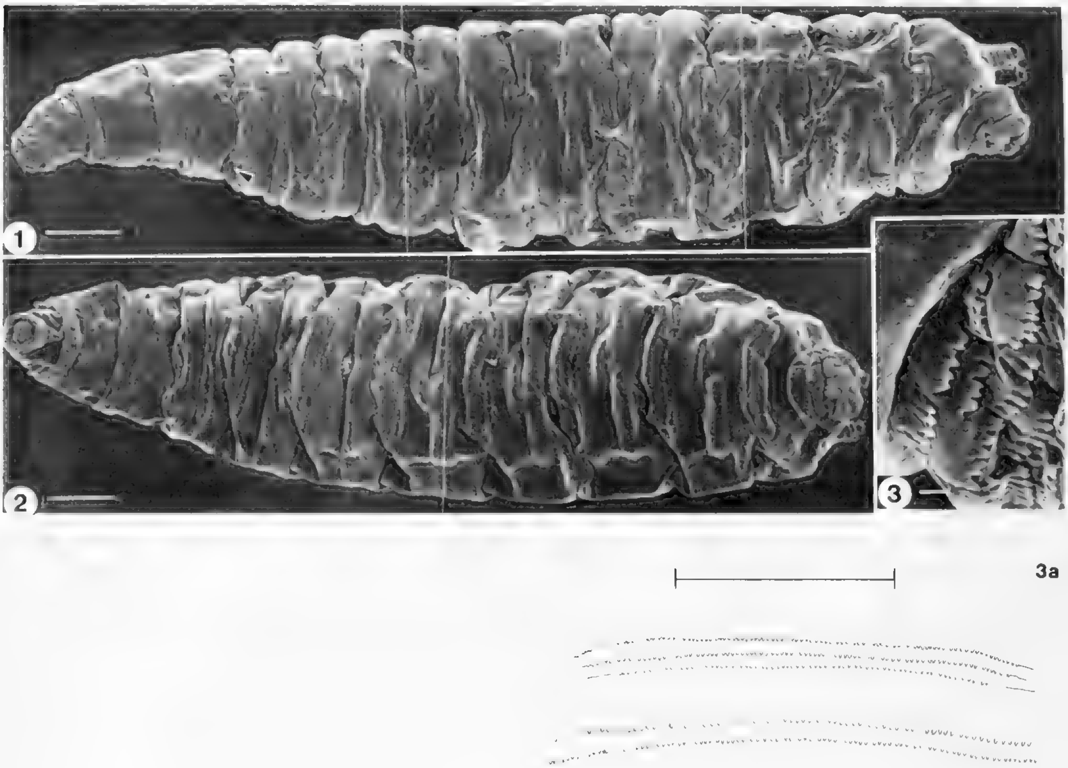
*Pseudogaurax* Malloch is a large, mostly tropical group (Sabrosky 1966) whose larvae are predators of the immature stages of several species of Araneae and Insecta. *Pseudogaurax signatus* (Loew) was originally placed in the genus *Gaurax* Loew. Sabrosky (1945, 1966) has provided the only taxonomic treatment on this group since Hall (1937) transferred the species to the genus *Pseudogaurax. P. signatus* has been reared from egg sacs of the spiders *Latrodectus mactans* (Fabr.), *Argiope riparia* (Lucas) and *Araneus* sp., oothecae of Mantidae (Davidson 1896, Hall 1937, Breland 1941), and the pupae of *Hyalophora cecropia* (L.) (Saturniidae) and *Euproctis chrysorrhoea* (L.) (Lymantriidae), (Sabrosky 1945).

Chloropid larvae display diverse feeding habits, including phytophagy, scatophagy, necrophagy, and predation. The larval stages of most chloropid species are unknown, and most available descriptions are for phytophagous species. The only known larval descriptions of predaceous chloropids are for *Steleocerellus latiseta* (Lamb) (Kirk-Spriggs 1986) and *Pseudogaurax anchora* (Loew) (Howard 1916); in the latter however, only the anterior spiracles and puparium were described. Roberts (1971) and Teskey (1981b) have emphasized that detailed larval descriptions of all immature stages together with descriptions of adults will undoubtedly be useful in elucidating phylogenetic relationships and the evolution of trophic diversity in this group of flies. We thus describe the third-instar larva of *Pseudogaurax signatus* (Loew).

## MATERIALS AND METHODS

One *Argiope* sp. egg sac was collected in the field and taken to the laboratory for dissection. A portion of the total number of third-instar larvae of *P. signatus* found within the egg sac were extracted, killed in KAAD, and preserved in 70% ethanol. The incision made in the egg sac was closed and the egg sac placed in a rearing chamber at room temperature until adult flies emerged.

For SEM examination, the larvae were dehydrated in ethanol and degreased in pentane. The specimens were then rehydrated, washed in 0.1 M phosphate buffer (pH 7.3), and postfixed in 2% osmium tetroxide in the same buffer. After dehydration in ethanol, specimens were critical point dried,



Figs. 1–3a. *Pseudogaurax signatus*, larva. 1, Lateral view. Line scale = 0.25 mm. 2, Ventral view. Line scale = 0.25 mm. 3, Spinules on anteroventral portion of 1rst abdominal segment (enlargement of area indicated by arrow in Fig. 1). Line scale = 10 μm. 3a, Spinule pattern on 4th abdominal segment (ventral view). Line scale = 0.05 mm.

mounted on stubs with silver paint and coated with gold-palladium in a Polaron e5100 sputter coater. The ultrastructure of the larva was studied with an Hitachi HHS-2R scanning electron microscope at an accelerating voltage of 20 kV.

For study of the cephalopharyngeal skeleton, larvae were cleared in 20% hot potas-

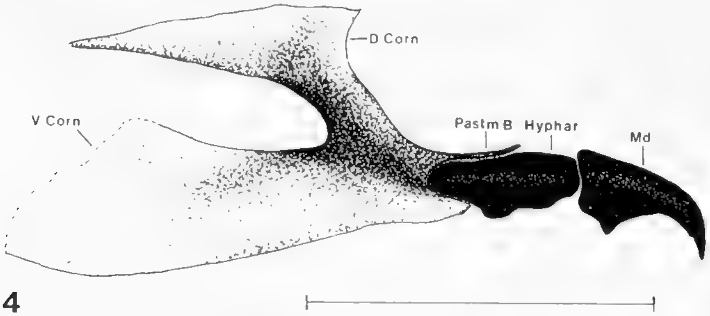
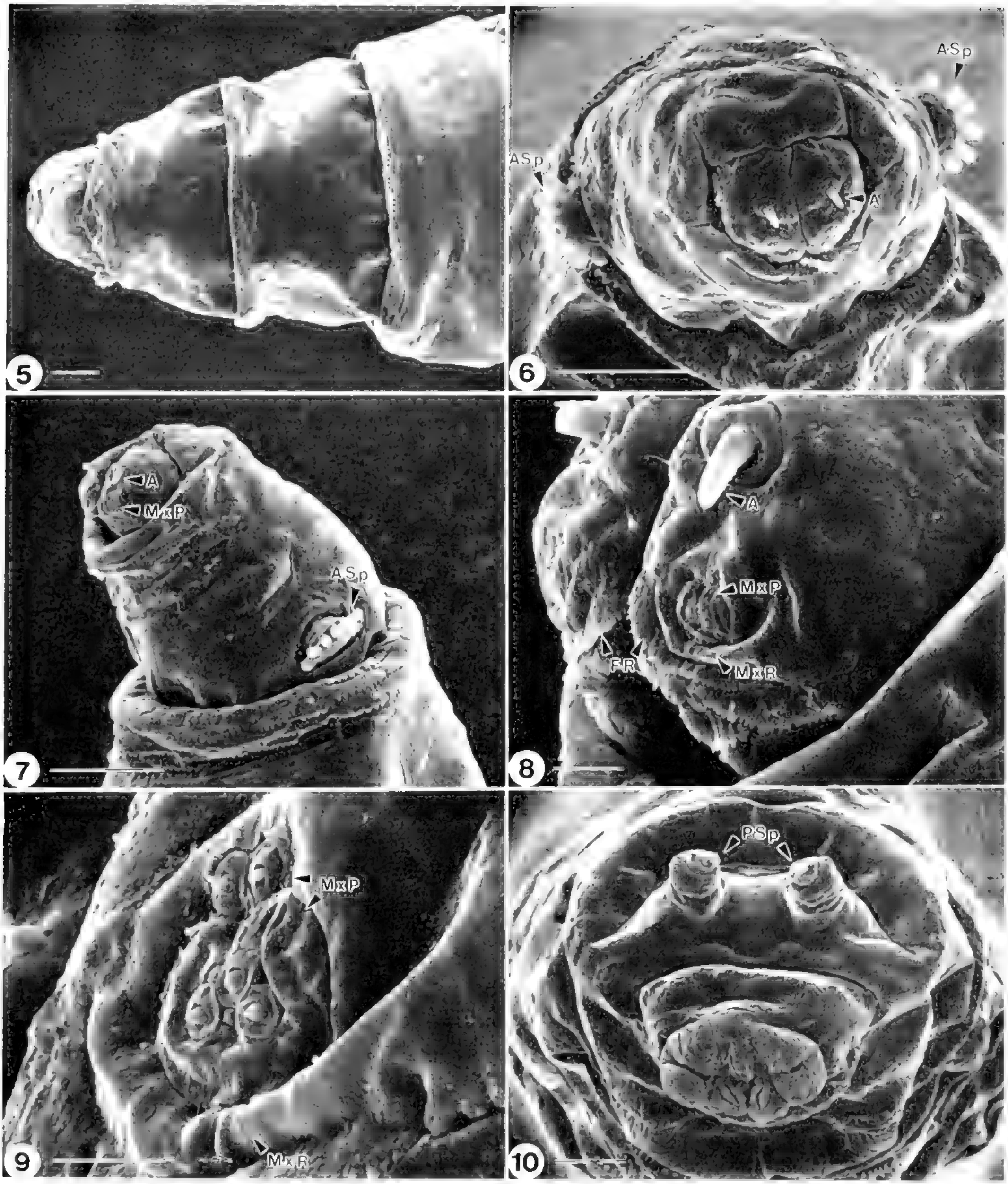


Fig. 4. *Pseudogaurax signatus*, larva, cephalopharyngeal skeleton (lateral view). D Corn = Dorsal Cornu, Hyphar = Hypopharyngeal Sclerite, Md = Mandible, Pastm B = Parastomal Bar, V Corn = Ventral Cornu. Line scale = 0.12 mm.



Figs. 5–11. *Pseudogaurax signatus*, larva. 5, Thorax, and first abdominal segment (dorsal view). 6, Head, facial mask (anterolateral view). 7, Head and prothorax (lateral view). 8, Head (ventrolateral view). 9, Maxillary palpus (ventrolateral view). 10, Anal plate (posterior view). Line scale for Figs. 5–7 = 100 μm. Line scale for Figs. 8–10 = 10 μm. A = Antenna, ASp = Anterior Spiracle, FR = Frontal Rami, MxP = Maxillary Palpus, MxR = Maxillary Ring, PSp = Posterior Spiracle. 11, Posterior spiracle (posterior view). Line scale = 0.05 mm.

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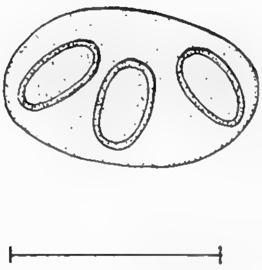

sium hydroxide, mounted on microscope slides in glycerine, and examined with an Olympus compound microscope.

## Description

Larva vermiform, tapering anterior of third abdominal segment, length 4.0–5.0 mm, greatest width 0.96 mm, creamy white; anterior margin of thoracic and first abdominal segments with several irregular rows of spinules on creeping welts (Figs. 1–3, 5). Spinules arranged in 5 regular but broken rows on ventral surface of abdominal segments 2–10; spinules coarse, oriented posteriorly, variable in size with those on 4th row larger (Fig. 3a); all abdominal segments with two annulations, thoracic segments without annulations.

Facial mask on cephalic segment bilobed, hooded by first thoracic segment (Figs. 6–7); frontal rami consisting of two oral ridges, serrate and overlapping (Fig. 8); antenna prominent, one-segmented, directed anteroventrally (Figs. 6–8); maxillary ring incomplete, forming a semicircle, opening dorsally; maxillary palpus in two sensillar groups (Figs. 8–9); a ventral triad is delimited by fleshy folds above the maxillary ring, abutting a dorsally located pair.

Mandibles of cephalopharyngeal skeleton separate, strongly sclerotized, basal portion deepest, narrowing distally, curved apically (Fig. 4); hypopharyngeal sclerite nearly same length as mandibles, similar in degree of melanization and sclerotization; parastomal sclerites slender, appearing as narrow bands above hypopharyngeal sclerite in lateral view, fused basally with tentoropharyngeal sclerite, but much less sclerotized; labial sclerite present, small, located between anterior ends of hypopharyngeal sclerites, not visible in lateral view; ventral cornu of tentoropharyngeal sclerite broader and longer than dorsal cornu, both processes heavily sclerotized along inner margins. Anterior spiracles palmate, with seven short papillae (Figs. 6–7); posterior spiracles 0.06 mm wide, convergent with protuberant bases 0.18 mm apart, three spiracular openings, oval, longitudinal axis of middle opening directed dorsally, lateral openings angled, longitudinal axes converging towards middle opening dorsally (Fig. 11); anal plate oval and fleshy (Fig. 10).

Specimens examined.—Larvae (n = 28): Label data Miss(issippi), Oktibbeha Co., Dorman Lake; 21 Jan(uary) 1986; Coll. Adam Asquith. Collected from *Argiope* sp. egg sac. Adults: (6 males, 7 females): Label data same as above except for second label: Reared from *Argiope* sp. egg sac. All voucher specimens are deposited in the Mississippi Entomological Museum at Mississippi State University.

## Discussion

The larva of *Pseudogaurax signatus* is comparable to that of *P. anchora*. Both lack the frond-like scales found on the posterior spiracles of other chloropid species such as *Meromyza laeta* Meigen (Fedoseyeva 1966), *Polyodaspis ruficornis* Macquart (Kiauka 1974), and *Ectocephala capillata* (Coquillet), (Deeming 1977, 1985). The antennae of *P. signatus* appear to be longer and more prominent than those of *P. anchora,* but being a contractile organ (Yamada et al. 1981) the variation in length may be a result of differential extension during fixation. We note that the terms antenna and maxillary palpi are adopted here because of their use in the taxonomic literature (Teskey 1981a), but these structures also represent the dorsal and terminal organs respectively of Bolwig (1946), that are commonly used in descriptive morphology (Chu-Wang and Axtell 1971, 1972, Yamada et al. 1981).

The spinules found on the body of *P. signatus* are typical for many described chloropid larvae. However, in *Meromyza* they are absent (Fedoseyeva 1966) and in *Polyodaspis ruficornis* Macquart the spinules are restricted to the ventral surface of the abdomen (Kiauka 1974). The mandibles of *P. signatus* are similar to those of the necrophagous chloropid *Conioscinella hinkleyi* (Malloch) (Norrbom 1983), and a predaceous species *Steleocerellus latiseta* (Lamb) (Kirk-Spriggs 1986), in being slightly more elongate and pointed than those of phytophagous larvae. Unfortunately, no other characters seem to indicate the predatory habits of this larva.

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# NEW SPECIES OF MICRO-CADDISFLIES (TRICHOPTERA: HYDROPTILIDAE) FROM NEW CALEDONIA, VANUATU AND FIJI

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*Abstract.* — New species of micro-caddisfly genera *Oxyethira* Eaton, *Paroxyethira* Mosely, *Acritoptila* Wells and *Caledonotrichia* Sykora are described from the South Pacific islands of New Caledonia, Vanuatu (Efate) and Fiji. Range extensions of genera *Paroxyethira* and *Acritoptila* are included and a new subgenus, endemic to New Caledonia, is added to the genus *Oxyethira.*

*Key Words:* caddisfly, new species, New Caledonia, Hydroptilidae

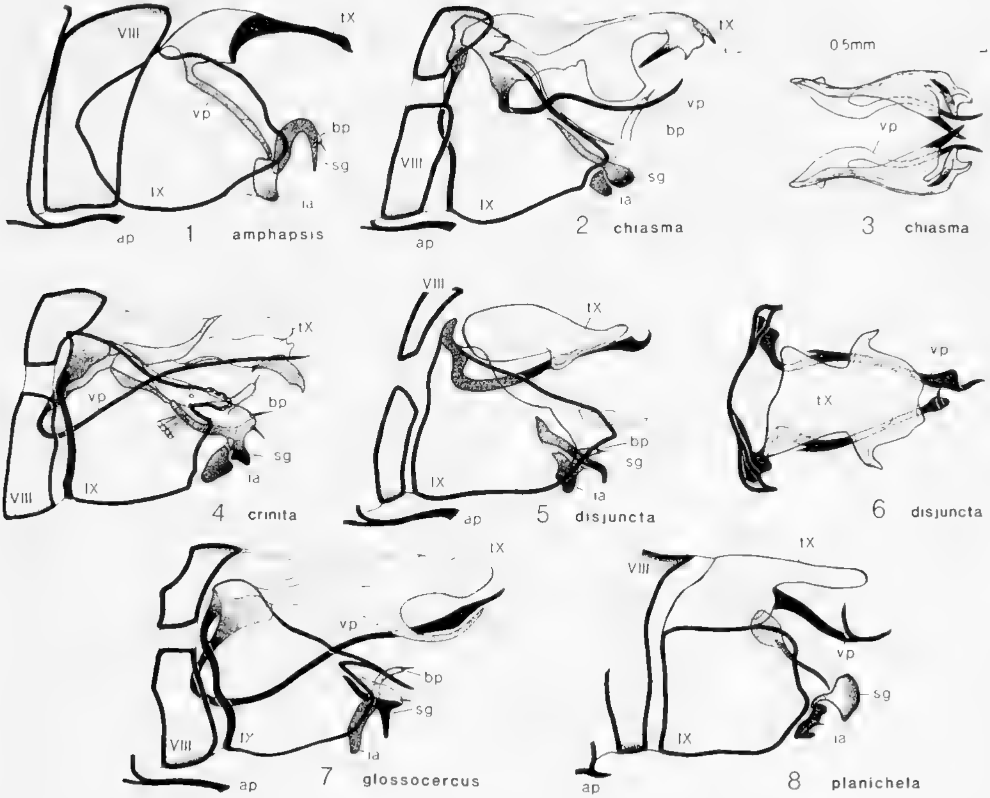
Numerous species of micro-caddisflies have been reported from the Australasian biogeographic region. Wells has noted a total of 12 micro-caddisfly genera from Australia: *Hydroptila* Dalman, *Oxyethira* Eaton, *Orthotrichia* Eaton, *Orphninotrichia* Mosely, *Maydenoptila* Neboiss, *Xuthotrichia* Mosely, *Hellyethira* Neboiss, *Austratrichia* Wells, and *Tricholeiochiton* (Kloet & Hincks). Only two hydroptilid genera, *Oxyethira* and *Paroxyethira,* are known from New Zealand and one genus, *Caledonotrichia* Sykora, from New Caledonia. Genera of the tribe Hydroptilini Stephens seem to be the predominant micro-caddisflies in the region. An examination of material from the Bishop Museum in Hawaii revealed previously unpublished species of four established hydroptilid genera on the Melanesian islands of New Caledonia, Efate (Vanuatu) and Fiji.

Described from New Caledonia are five new species of *Oxyethira,* two new species of *Caledonotrichia* and six new species of *Acritoptila.* This brings to 17 the number of species, distributed among four genera, of micro-caddisflies known from the island. One new species of *Oxyethira* is described from Vanuatu and one from Fiji. These discoveries extend the range of *Oxyethira* to include Melanesia, of *Paroxyethira* to include New Caledonia as well as New Zealand, and of *Acritoptila* which was previously considered endemic to Australia. New species of *Oxyethira* from Melanesia include species in the subgenus *Trichoglene* Neboiss and a new subgenus, *Pacifica.* The collections also showed a high incidence of endemism at the species level in New Caledonia. The length and number of antennal segments were unavailable for several species. All type specimens are deposited in the Bishop Museum in Hawaii.

### Genus *Acritoptila* Wells, 1982

*Type species: Acritoptila globosa* Wells, 1982, by original designation.

Six New Caledonian species of the genus *Acritoptila* are described below. This genus in the *Hellyethira* complex of genera, was previously known only from Australia, with two species in Western Australia and one species in Queensland. The males of these



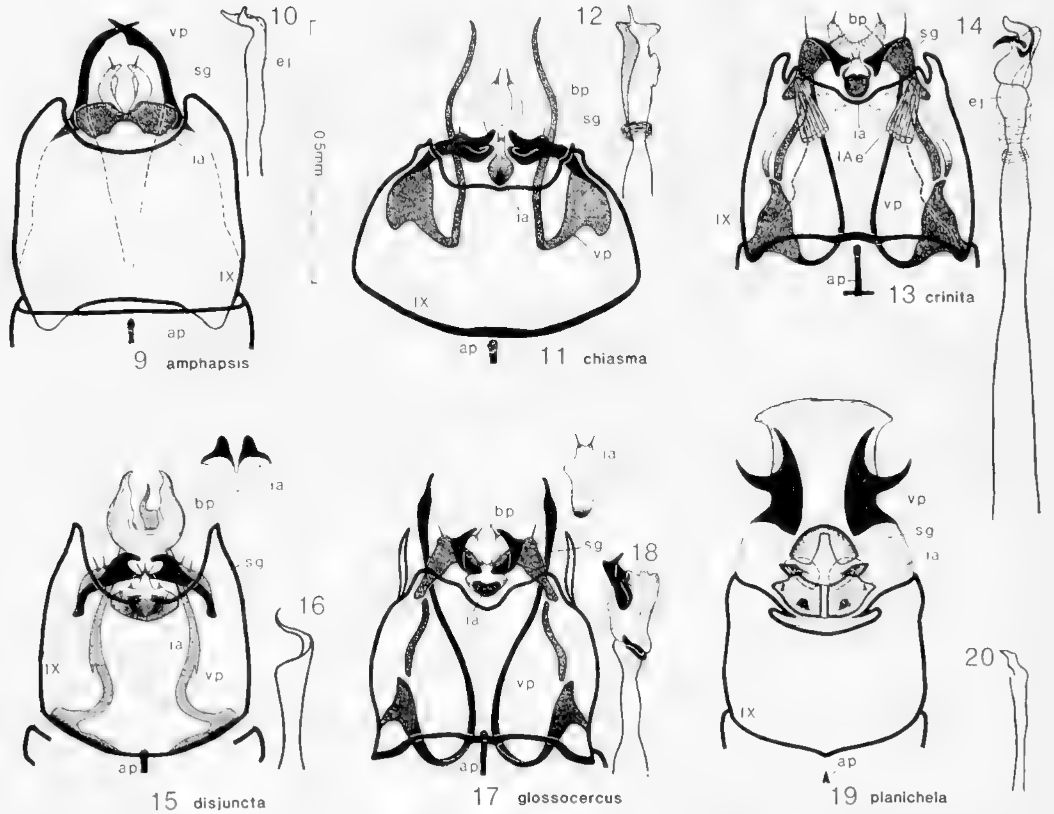
Figs. 1–8. Male terminalia of *Acritoptila* Wells, lateral and dorsal views. *A. amphapsis*: 1, lateral. *A. chiasma*: 2, lateral; 3, tergum X (dorsal). *A. crinita*: 4, lateral. *A. disjuncta*: 5, lateral; 6, tergum X (dorsal). *A. glossocercus*: 7, lateral. *A. planichela*: 8, lateral. ap, apico-mesal process; bp, bilobed process; ia, inferior appendages; sg, subgenital processes; tX, tergum X; vp, ventrolateral process.

new species share with the Australian species of the genus, fused inferior appendages (Fig. 17); a complex tergum X with spines and projections (Fig. 3) and long rod-like processes (Fig. 7), described as parameres by Wells (1982), projecting from the lateral margin of tergum X. In most of the new species the fusion of the inferior appendages is more complete than in the Australian species. Females, although not described here, share with the *Hellyethira* generic complex shortened apodemes on segments VIII and IX. The spur formula, wing venation and other characters of the new species are consistent with the generic description by Wells (1982).

### *Acritoptila amphapsis*, New Species

Figs. 1, 9, 10

Male.—Length 2.7 mm. Segment VII: apico-mesal process of venter elongate. Segment IX: pleuron produced into blunt posterior lobe; venter excised anteriorly and posteriorly. Segment X: dorsum split near base into sclerotized processes which converge at apices; ventrolateral processes reaching base of subgenital processes. Inferior appendages: truncate, joined by narrow bridge. Subgenital processes: convergent, arch-shaped in lateral view. Aedeagus (Fig. 10): elongate, bifurcate apically.



Figs. 9–20. Male terminalia of *Acritoptila* Wells, aedeagus and ventral views. *A. amphapsis*: 9, ventral; 10, aedeagus. *A. chiasma*: 11, ventral; 12, aedeagus. *A. crinita*: 13, ventral; 14, aedeagus. *A. disjuncta*: 15, ventral with inset of caudal view of inferior appendages; 16, aedeagus. *A. glossocercus*: 17, ventral; 18, aedeagus. *A. planichela*: 19, ventral; 20, aedeagus. ap, apico-mesal process; bp, bilobed process; ej, ejaculatory duct; ia, inferior appendages; IAe, inferior appendage extensor muscle; sg, subgenital processes; vp, ventrolateral processes.

Female.—Unknown.

Etymology.—Named for the arch-shaped subgenital processes.

Holotype.—Male. New Caledonia: Honailu River, 26 Oct. 1958, C. R. Joyce.

Paratypes.—None.

Diagnosis.—The semi-fused inferior appendages (Fig. 9) and relatively short ventrolateral lobes of tergum X (Fig. 1) are more similar to male genitalia of the Australian *Acritoptila* than to the genitalia of other New Caledonian species.

### *Acritoptila chiasma*, New Species

Figs. 2, 3, 11, 12

Male.—Antennae 34 segmented. Segment VIII: ventral apico-mesal process elongate. Segment IX: pleuron with narrow sclerotized process on lateral margin. Tergum X: elaborately sculptured with mesal, blackened tips and elongate ventrolateral rod-like processes (Fig. 3). Inferior appendages: completely fused; membranous caudal lobe with 2 short setae. Subgenital processes: mesal margin bilobed, with inner lobe auriculate; single lateral seta; bilobed process with long lobes. Aedeagus: apex largely membranous with small apical point (Fig. 12).

Female.—Unknown.

Etymology.—Named for the membranous mesal area dividing tergum X into right and left halves.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same as holotype, 26 ♂. Plateau du Dogny, 20 Nov. 1958, 1 ♂.

Diagnosis.—This species is most closely related to the New Caledonian *A. glossocercus* and *A. crinita*. Like those species, it bears a lateral process on pleuron IX. But, the tenth tergum is quite distinctive.

### *Acritoptila crinita*,
### New Species

Figs. 4, 13, 14

Male.—Segment VII: ventral apico-mesal process elongate (AP). Segment VIII: dorsum with lateral fringe of elongate setae (not in illustration). Segment IX: lateral process short, broad, setose. Tergum X: largely membranous except for sclerotized lateral margin and caudolateral process. Inferior appendages: completely fused into rounded structure (ventral view); membranous caudal lobe with two short setae. Subgenital processes: mesally bifid and blackened; two lateral setae; rod-like sclerite connecting lateral lobes of subgenital processes to base of tergum X; bilobed process with short lobes covered with minute setae. Inferior appendages: extensor muscle inserted on lateral lobe of subgenital processes. Aedeagus: apex with several sclerotized processes (Fig. 14).

Female.—Unknown.

Etymology.—Named for long fringe of setae on dorsum VIII.

Holotype.—Male. New Caledonia: headwaters of Honailu River, 26 Oct. 1958, C. R. Joyce.

Paratypes.—None.

Diagnosis.—This species is a sister species of *A. glossocercus*, with nearly identical ventrolateral rod-shaped processes on tergum X (Figs. 4, 7). It may be distinguished from *A. glossocercus* by the rounded fused inferior appendages (Fig. 13), the setose bilobed process (Fig. 13) and the non-dilated caudolateral processes of tergum X (Fig. 4).

### *Acritoptila disjuncta*,
### New Species

Figs. 5, 6, 15, 16

Male.—Antennae 35 segmented. Segment IX: pleuron acutely pointed; venter broadly excised. Tergum X: ventral processes broadened distally with narrow pointed lobe, asymmetrical; remainder of tergum membranous. Inferior appendages: fused and broadly oval in ventral view; membranous mesal lobe with 3 setae at tip and one short seta laterad of base of lobe on each side. Subgenital processes: mesally connected dorsad of inferior appendages and with convergent distal processes; paired caudolateral setae; apices directed ventrally; bilobed process short. Aedeagus: simple, with distal sinuate process.

Female.—Unknown.

Etymology.—Named for the appearance that tergum X is not joined to segment IX.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 5 ♂. New Caledonia, Plaine des Lacs area, 3 Nov. 1958, C. R. Joyce.

Diagnosis.—This species is grouped with *chiasma, crinita* and *glossocercus* because the males bear an elongate ventrolateral process on tergum X. It differs because its processes are thicker and asymmetrical, and the inferior appendages are broad.

### *Acritoptila glossocercus*,
### New Species

Figs. 7, 17, 18

Male.—Segment VII: ventral apico-mesal process elongate. Segment IX: lateral process of pleuron attenuate, moderate in length. Tergum X: largely membranous, with curved lateral process; elongate ventrolateral rod-shaped processes widened subapically. Inferior appendages: completely fused; tongue-shaped in caudal view; membranous caudal lobe with two short setae. Subgenital processes: mesally heavily sclerotized and bilobed; one lateral seta; bilobed process with short lobes. Aedeagus: single apical sclerotized process (Fig. 18).

Female.—Unknown.

Etymology.—Named for the tongue-shaped inferior appendages.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—None.

Diagnosis.—A sister species of *A. crinita,* with similar ventrolateral rod-shaped processes on tergum X (Figs. 4, 7), this species may be most easily recognized by the dilated condition of these processes (Fig. 7) and the tongue-shaped inferior appendages (caudal view—Fig. 17)

### *Acritoptila planichela,*
### New Species

Figs. 8, 19, 20

Male.—Segment VII. Apico-mesal process of venter short, acutely pointed. Segment IX: pleuron truncate; venter anteriorly truncate. Tergum X: distally flared with ventral flat, heavily sclerotized, claw-shaped processes. Inferior appendages: fused into broad plate with pair of ventral protuberances and single spine at each lateral margin. Sclerotized subgenital structure ventrad of aedeagus, with narrow sclerotized band connecting it to tergum X. Aedeagus: simple, elongate, lacking titillator (Fig. 20).

Female.—Unknown.

Etymology.—Named for the flat claw of tergum X.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 2 ♂.

Diagnosis.—This is the most divergent of the New Caledonian species of *Acritoptila.* The subgenital structures are difficult to homologize with the subgenital processes of other species of *Acritoptila.* It is the only species in the genus with a short apico-mesal process of venter VII. Relationships with other New Caledonian *Acritoptila* are unclear.

## Genus *Caledonotrichia* Sykora, 1967

*Type species: Caledonotrichia iiliesi* Sykora, 1967.

As noted by Wells (1983), males of *Caledonotrichia* closely resemble those of *Maydenoptila* Neboiss. Indeed, if only genitalic characters are analyzed, the two genera could be synonymous. Adult males of *Caledonotrichia* may be distinguished by the paired subgenital processes. In *Maydenoptila,* the subgenital processes are fused or absent. *Caledonotrichia* species have a transverse suture on the mesoscutellum, as do *Maydenoptila* species. In the generic description given by Marshall (1979), the suture was described as absent in *Caledonotrichia.*

### *Caledonotrichia charadra,*
### New Species

Figs. 21–23

Male.—Segment IX: anterior and caudal margins of venter truncate; pleuron sinuate; dorsum a broad band. Subgenital processes: parallel, contiguous, caudally spatulate in ventral view and anteriorly divergent. Membranous sac within segment IX. Inferior appendages: bilobed and attached to dorsolateral margin of segment IX; upper lobe sickle-shaped with blackened, ventrally directed tooth on mesal margin; ventral lobe triangular in shape. Aedeagus: largely membranous with elongate sclerotized process originating at base of aedeagus (Fig. 23).

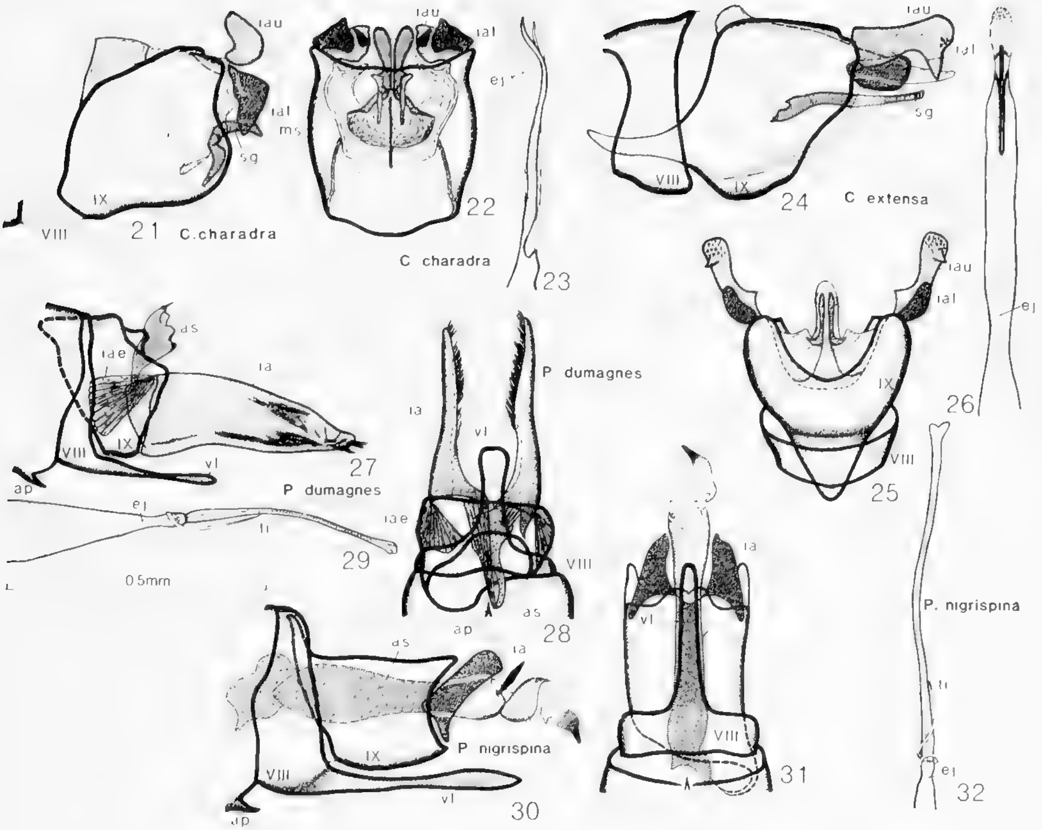
Female.—Unknown.

Etymology.—Named habitat of holotype in mountain stream.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 31 ♂.

Diagnosis.—This species is closely related to *C. minor* Sykora, particularly in the shape of the inferior appendages and ae-



Figs. 21–32. Male terminalia of *Caledonotrichia* Sykora and *Paroxyethira* Mosely. *C. charadra*: 21, lateral; 22, ventral; 23, aedeagus. *C. extensa*: 24, lateral; 25, ventral; 26, aedeagus. *P. dumagnes*: 27, lateral; 28, ventral; 29, aedeagus. *P. nigrispina*: 30, lateral; 31, ventral; 32, aedeagus. ap, apio-mesal process; as, aedeagal sheath; ej, ejaculatory duct; ia, inferior appendages; iae, inferior appendage extensor muscle; ial, inferior appendage lower lobe; iau, inferior appendage upper lobe; ms, membranous sac; sg, subgenital process; ti, titillator; vl, ventral lobe.

deagus. It may be distinguished by the shape of the subgenital processes.

### *Caledonotrichia extensa*, New Species

Figs. 24–26

Male.—Antennae 27 segmented. Segment IX: venter protruded anteriorly within segment VIII; caudal margin broadly excised. Subgenital processes: elongate and narrow. Tergum X: elongate, tongue-shaped. Inferior appendages: bilobed; attached to dorsolateral margin of segment IX; dorsal lobe long, with ventrally directed tooth and peg-like setae at base; ventral lobe broadly oval. Aedeagus: elongate; dorsal crease along most of length; membranous lobe extends distally beyond tip of ejaculatory duct.

Female.—Unknown.

Etymology.—Named for divergent condition of inferior appendages.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 1 ♂.

Diagnosis.—*C. extensa* is distinctive, with the lobes of the inferior appendages longer than wide. It is likely a sister to the distinct group composed of the other species in the genus.

### Genus *Oxyethira* Eaton, 1873
Subgenus *Trichoglene* (Neboiss, 1977)

*Type species: Oxyethira albiceps* (MacLachlan, 1862).

Two species of *Oxyethira* from New Caledonia are placed in subgenus *Trichoglene* Neboiss along with the New Zealand *O. albiceps* and the Australian *brevis* Wells, *columba* (Neboiss), *mienica* Wells, *triangulata* Wells and *retracta* Wells. Males of the two new species share with these other species a plesiomorphic character; a complete, non-excised segment VIII, and two apomorphic characters; aedeagus with recurved sub-distal spinous process and subgenital processes widely separated and partly fused with each pleuron of segment IX. Males of *O. caledoniensis* n. sp. are similar to *O. brevis* in having a short titillator, but seem to be more primitive than all Australian and New Zealand species in the retention of a sclerotized mesal connection between the subgenital processes. *O. insularis* n. sp. males are aberrant, with an enlarged forked structure, apparently the modified inferior appendages, on elongate venter IX. The forked structure is like that found in males of the subgenus *Dactylotrichia* Kelley but is probably not homologous.

The type species of *Trichoglene* was incorrectly identified as *O. columba* (Neboiss) in Kelley (1984). It should be *O. albiceps* (MacLachlan). A redescription of the subgenus was given in Kelley (1984).

### *Oxyethira caledoniensis*, New Species
Figs. 33, 42, 56

Male.—Segment VIII: cylindrical, without excisions. Segment IX: dorsum narrow in lateral view; venter reaching anterior end of segment VIII. Inferior appendages: reduced to small, widely separated bilobed areas of sclerotization. Subgenital processes: widely separated, narrow, connected by thin mesal sclerotized strip; dorsolaterally fused to pleuron IX; bilobed processes short. Aedeagus: titillator short; recurved subdistal process.

Female.—Unknown.

Etymology.—Named for island where holotype was collected.

Holotype.—Male. New Caledonia: Plum, 20–60 m, malaise trap, 23–25 Mar. 1968, J. L. Gressitt & T. C. Maa.

Paratypes.—None.

### *Oxyethira insularis*, New Species
Figs. 34, 43, 57

Male.—Length 1.7 mm. Segment VIII: cylindrical, without excisions. Segment IX: dorsum broad; venter elongate, reaching anterior end of segment VII; venter with large forked process, fused inferior appendages, subtending membranous, serrately tipped plate. Subgenital processes: acutely pointed, connected mesally by curved sclerotized band and connected dorsolaterally to pleuron IX; bilobed processes short. Aedeagus: titillator lacking; sclerotized, recurved processes at apex.

Female.—Unknown.

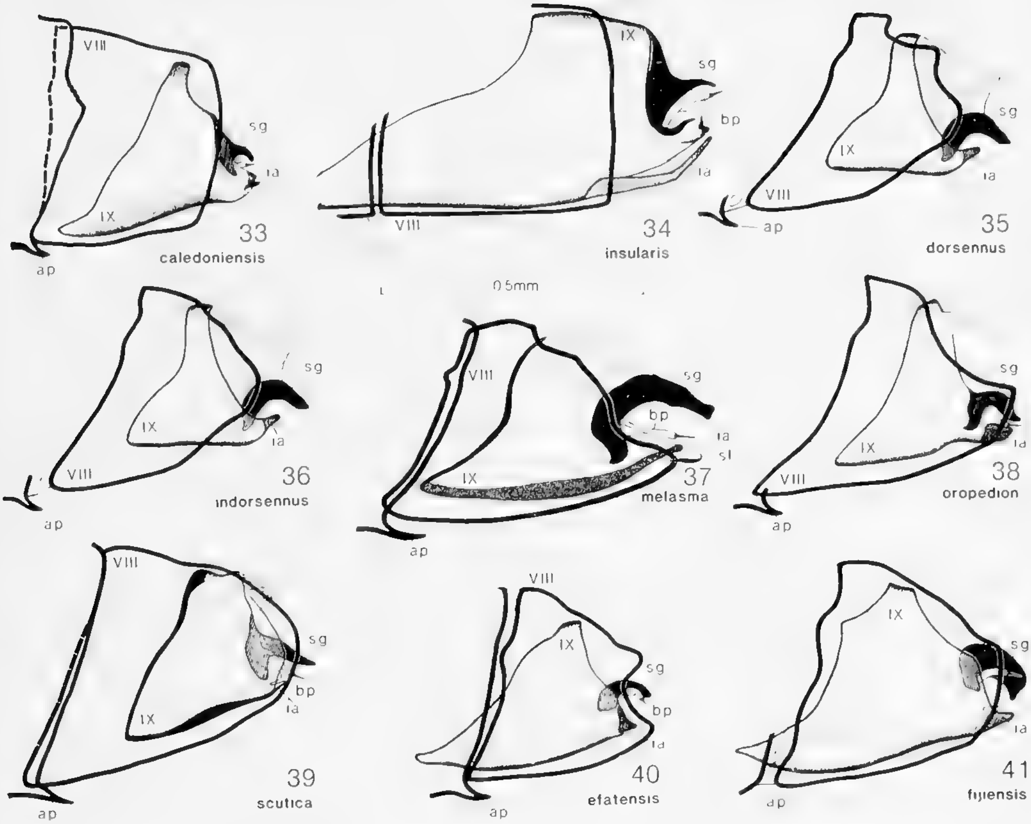
Etymology.—Named for its island habitat.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 1 ♂.

### Genus *Oxyethira* Eaton, 1873
Subgenus ***Pacificotrichia*, n. subgen.**

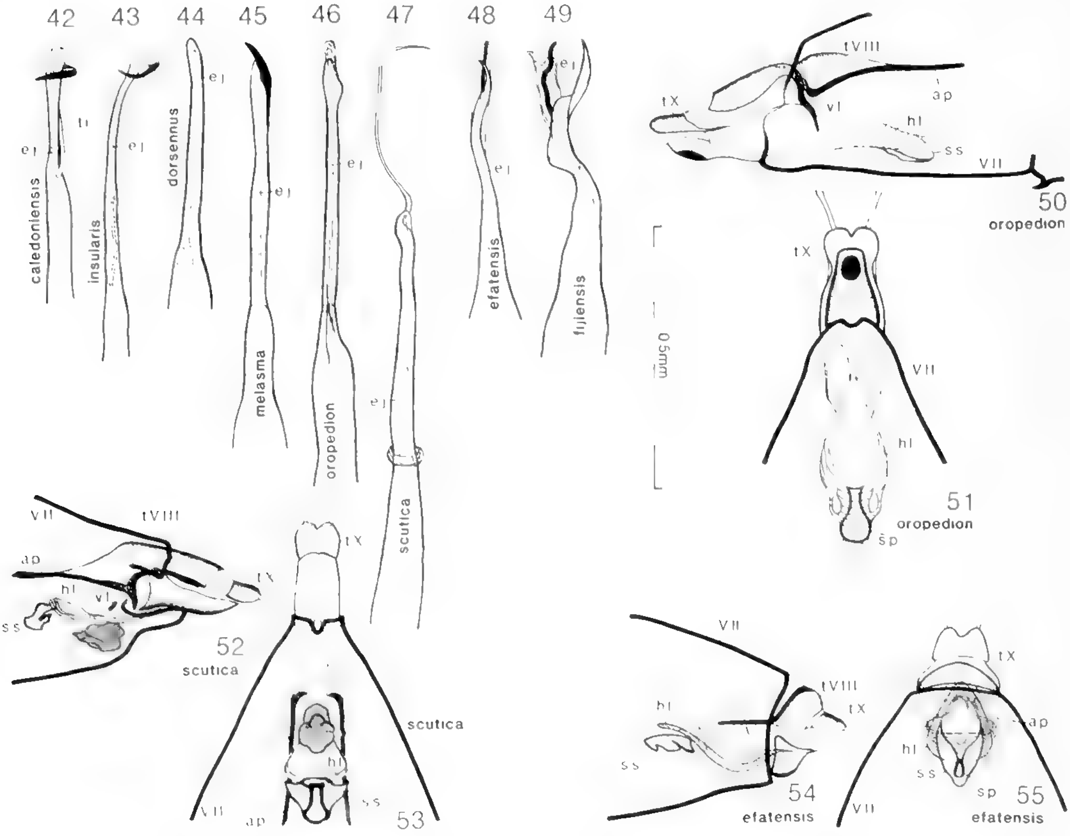
Seven new species of *Oxyethira* from New Caledonia, Vanuatu and Fiji are arranged here in a new subgenus endemic to the South Pacific islands. Relationships with other subgenera are unclear, although *Pacificotrichia* is most similar to *Dampfitrichia* Mosely. Similarities between the males include the shallowly excised venter VIII (Fig. 62), the deeply excised dorsum VIII (Fig. 37), fused $R_4$ and $R_5$ forewing veins, configura-



Figs. 33–41. Male terminalia of *Oxyethira* Eaton, lateral views. 33, *O. caledoniensis.* 34, *O. insularis.* 35, *O. dorsennus.* 36, *O. indorsennus.* 37, *O. melasma.* 38, *O. oropedion.* 39, *O. scutica.* 40, *O. efatensis.* 41, *O. fijiensis.* ap, apico-mesal process; bp, bilobed process; ia, inferior appendages; sg, subgenital processes; sl, tapered seta.

tion of the subgenital processes, and reduction or loss of the pre-apical spur on the meso-tibia. The relatively simple male genitalia, with a reduced ninth segment, are like the genitalia of the minima group of subgenus *Dampfitrichia,* the only other known Australasian group of *Oxyethira* besides the endemic subgenus *Trichoglene.* But, there are important differences: unlike males of the minima group, the subgenital processes are distally fused (Fig. 56), do not bear distal setae (Fig. 63) and retain the bilobed process. The lack of significant shared apomorphies prohibit the placement of these species in subgenus *Dampfitrichia.*

Two distinct groups can be identified in subgenus *Pacificotrichia.* The oropedion group includes species *O. dorsennus* n. sp., *indorsennus* n. sp., *melasma* n. sp., *oropedion* n. sp. and *scutica* n. sp. In males of these species, venter IX does not reach the anterior end of segment VIII (Fig. 35) and the fused subgenital processes bear a pronounced mesodistal projection (Fig. 58). Females are characterized by elongate apodemes (Fig. 50) and cerci (Fig. 53), as well as by a sclerotized lateroventral projection on tergum VIII. The efatensis group includes *O. efatensis* n. sp. and *fijiensis* n. sp. Males of this group are distinguished by venter IX which extends into segment VII (Fig. 40), subgenital processes which are not connected anteromesally (Fig. 63) and an aedeagus with a tapered dorsal sclerotized



Figs. 42–55. Aedeagi and female terminalia of *Oxyethira* Eaton. Figs. 42–49, aedeagi. 42, *O. caledoniensis.* 43, *O. insularis.* 44, *O. dorsennus.* 45, *O. melasma.* 46, *O. oropedion.* 47, *O. scutica.* 48, *O efatensis.* 49, *O fijiensis.* Figs. 50–53, female terminalia. *O. oropedion:* 50, lateral; 51, ventral. *O. scutica*: 52, lateral; 53, ventral. *O. efaensis*: 54, lateral; 55, ventral. ap, apodeme IX; ej, ejaculatory duct; hl, horizontal lamella; sp, spermathecal process; ss, spermathecal sclerite; ti, titillator; tX, tergum X; vl, ventral lobe.

process and a membranous ventral tube (Fig. 49). Females bear short apodemes and cerci (Fig. 54).

### Subgenus *Pacificotrichia,* n. subgen.

*Type species:* ***Oxyethira oropedion,*** **n. sp.**

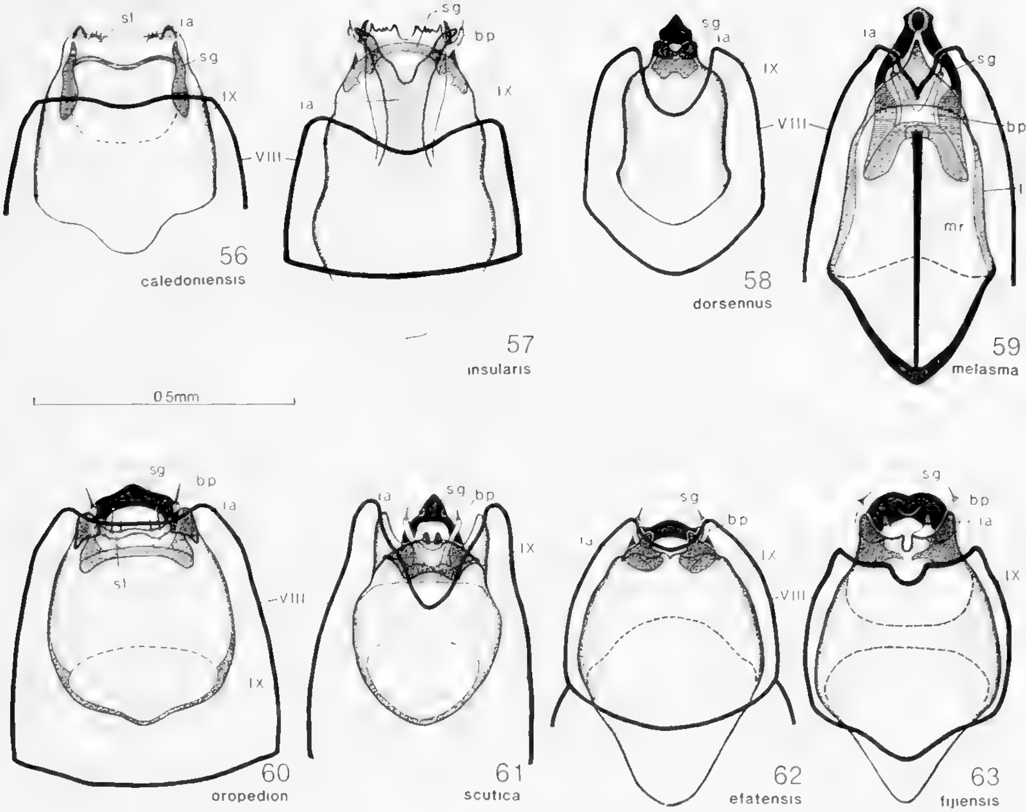
*Spur formula:* 0-2-4 or 0-3-4.

*Forewings:* $R_4$ and $R_5$ fused.

Male.—Length 2.1–2.4 mm. Antennae 24–30 segmented; sparse placoid sensilla. Segment VIII: venter shallowly excised (Fig. 63); dorsum deeply excised. Segment IX: dorsum narrow (Fig. 40); posterolateral processes lacking; venter reaching to anterior end of segment VIII or posterior end of segment VII (Figs. 37, 40). Inferior appendages: small or lacking (Fig. 40); setal lobes usually indistinct. Subgenital processes: fused distally (Fig. 63); bilobed process short (Fig. 62). Aedeagus: titillator absent (Fig. 48).

Female.—There is too much variability among females to describe subgeneric characters.

Range.—New Caledonia; Vanuatu; Fiji.



Figs. 56–63. Male terminalia of *Oxyethira* Eaton, ventral views. 56, *O. caledoniensis*. 57, *O. insularis*. 58, *O. dorsennus*. 59, *O. melasma*. 60, *O. oropedion*. 61, *O. scutica*. 62, *O. efatensis*. 63, *O. fijiensis*. bp, bilobed process; ia, inferior appendages; mr, mesal ridge; sg, subgenital processes; sl, setal lobe.

## *oropedion* Group

### ***Oxyethira dorsennus,*** New Species

Figs. 35, 44, 58

*Spur formula:* 0-2-4.

Male.—Length 2.1 mm. Antennae 25 segmented. Segmented VII: ventral apico-mesal process present. Segment VIII: dorsum with deep excision in lateral view. Inferior appendages: darkened, nearly contiguous mesally. Subgenital processes: triangular fused apex. Aedeagus: lacking distal processes.

Female.—Unknown.

Etymology.—Named for the hump on dorsum VIII.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 1 ♂. New Caledonia, Plum, 20–60 m, 23–25 Mar. 1958, 1 ♂.

### ***Oxyethira indorsennus,*** New Species

Figs. 36, 44, 58

*Spur formula:* 0-3-4.

Male.—Length 2.1 mm. Antennae: 25 segmented. Segment VII: ventral apico-mesal process present. Segment VIII: dorsum gradually excised in lateral view. Inferior appendages: darkened, nearly contiguous mesally. Subgenital processes: triangular fused apex. Aedeagus: lacking distal processes.

Female.—Unknown.

Etymology.—Named for absence of dorsal hump on dorsum VIII.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 5 ♂.

Diagnosis.—This species differs from *O. dorsennus,* n. sp. only in the shape of dorsum VIII (Figs. 35, 36) and the spur formula.

### *Oxyethira melasma,*
### New Species

Figs. 37, 45, 59

*Spur formula:* 0-2-4.

Male.—Antennae: 23–30 segmented. Segment VII: ventral apico-mesal process large. Segment VIII: venter with shallow, acutely pointed excision; setae stout with tapered curved apices. Segment IX: venter with mesal ridge, caudal end tapered to acutely pointed tip; dorsum membranous. Inferior appendages: indistinct; setal lobes lacking. Subgenital processes: with ventral black spot at fused apex; elongate bilobed process with mesally contiguous lobes. Aedeagus: apical sclerotized process.

Female.—Unknown.

Etymology.—Named for the black spot on the subgenital processes.

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 1 ♂. New Caledonia, Honailu River headwaters, 26 Oct. 1958, 1 ♂.

### *Oxyethira oropedion,*
### New Species

Figs. 38, 46, 50, 51, 60

*Spur formula:* 0-3-4.

Male.—Antennae: 26 segmented. Segment VII: ventral apico-mesal process present. Segment VIII: venter not excised; dorsum deeply excised. Inferior appendages: widely separated; setal lobes forming setose membranous bridge between inferior appendages. Aedeagus: without apical processes.

Female.—Segment VIII: tergum and apodemes elongate; sternum with ventral black spot. Spermathecal sclerite indistinct.

Etymology.—Greek for plateau, the holotype habitat.

Holotype.—Male. New Caledonia: Plateau de Dogny, light trap, 20 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 1 ♂.

Diagnosis.—In ventral aspect, the males are distinguished by the combination of widely separated inferior appendages and broad subgenital processes. The females are easily distinguished by the black spot on sternum VIII.

### *Oxyethira scutica,*
### New Species

Figs. 39, 47, 52, 53, 61

*Spur formula:* 0-2-4.

Male.—Antennae: 26 segmented. Segment VII: ventral apico-mesal process present. Segment VIII: pleuron roundly truncate; venter moderately excised. Inferior appendages: minute contiguous lobes at caudal tip of venter IX; setal lobes lacking. Subgenital processes: with paied black spots bordering caudomesal protrusion; bilobed process with elongate lobes. Aedeagus: narrow elongate process extending from apex.

Female.—Antennae: 20 segmented. Segment VIII: tergum and apodemes elongate. Spermathecal process distinct. Sclerotized sac present caudad of spermathecal process.

Etymology.—Named for the elongate whip-like process of the aedeagus (Fig. 47).

Holotype.—Male. New Caledonia: mountain stream up Boulari River, light trap, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 3 ♂. Same locality as holotype, 17 Nov. 1958, 17 ♂.

Diagnosis.—Males of this species may be recognized by the minute inferior appendages and triangular (ventral view) subgenital processes, in addition to the shape of the aedeagal process. *Oxyethira scutica* is the only species of subgenus *Pacificotrichia* with paired black teeth along the posterior fused margin of the subgenital processes. This character is common among species of other neotropical subgenera of *Oxyethira*.

### *efatensis* Group

### ***Oxyethira efatensis*, New Species**

Figs. 40, 48, 54, 55, 62

*Spur formula:* 0-3-4.

Male.—Length 2.4 mm. Antennae 26 segmented. Segment VII: ventral apico-mesal process present. Segment VIII: venter and pleuron slightly excised. Inferior appendages: triangular in shape, discrete. Aedeagus: with dorsal, sclerotized, attenuate band subtended by membranous tube (Fig. 48).

Female.—Length 2.4 mm. Antennae 21 segmented. Segment VIII: tergum short with anterior margin heavily sclerotized. Segment IX: lacking. Spermathecal process teardrop-shaped; horizontal lamella distinctly sclerotized.

Etymology.—Named for locality of collection.

Holotype.—Male. Vanuatu: Efate (NW), Maat, Ambryn Village, 3M., 18 Aug. 1957, light trap, J. L. Cressitt.

Paratypes.—Same data as holotype, 4 ♂. Same locality as holotype, 19 Aug. 1957, 5 ♂.

Diagnosis.—This species may be distinguished from *O. fijiensis* n. sp. by the excised pleuron VIII and the median ventral projection of the fused subgenital processes.

### ***Oxyethira fijiensis*, New Species**

Figs. 41, 49, 63

*Spur formula:* 0-3-4.

Male.—Segment VII: ventral apico-mesal process lacking. Segment VIII: venter with small mesal excision; pleuron truncate. Segment IX: pleuron with dorsolateral point on anterior margin; venter pointed anteriorly. Inferior appendages: small, indistinct, widely separated. Subgenital processes: fused caudal margin with mesal tooth. Aedeagus: one sclerotized blade-like process and one membranous process enclosing ejaculatory duct (Fig. 49).

Female.—Unknown.

Etymology.—Named for collection locality of holotype.

Holotype.—Male. Fiji: Levu, Nandarivatu, Jan. 1955, N. L. H. Krauss.

Paratypes.—None.

Diagnosis.—This species may be distinguished by the distomesal tooth on the subgenital processes.

## **Genus *Paroxyethira* Mosely, 1924**

The two new species of *Paroxyethira* Mosely described here are the first known from this genus outside New Zealand. Both species are similar to previously described species of *Paroxyethira* in the morphology of the terminal abdominal segments as well as wing venation, spur formula and other non-genitalic characters. The genus is characterized by the elongate ventral process of segment VIII (Fig. 30) and the asymmetrical aedeagal sheath in the males (Fig. 30). A description of the genus was given by Marshall (1979).

### ***Paroxyethira dumagnes* New Species**

Figs. 27, 29, 31

Male.—Antennae 25 segmented. Segment VII: ventral apico-mesal process present. Segment VIII: length short; venter with elongate spatulate process; pleuron with elongate setae. Segment IX: dorsum asymmetrical and tilted anteriorly; pleuron protruded caudally. Inferior appendages: elongate with numerous black setae on inner margin; extensor muscles originate on anterior pleuron IX and insert on anterolateral corners of inferior appendages. Aedeagus:

sheath short, asymmetrical, with several short setae and a long anterior apodeme; one muscle originates caudally on venter IX and inserts on apex of apodeme, another inserts on caudal end of sheath; aedeagus elongate, with titillator and two distal lobes.

Female.—Unknown.

Etymology.—Named for the inferior appendages, which have black setae which appear like magnetic filings.

Holotype.—Male. New Caledonia: Boulari River, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 2 ♂. Same locality as holotype, 17 Nov. 1958, 165 ♂.

Diagnosis.—*Paroxyethira dumagnes* males have a short aedeagal sheath with an anterior apodeme (Fig. 27) as do males of *P. tillyardi* Mosely. However the apex of the aedeagal sheath is different from all other known species of the genus.

### *Paroxyethira nigrispina*, New Species

Figs. 30–32

Male.—Antennae 22 segmented. Segment VII: short ventral apico-mesal process present. Segment VIII: length short; venter with elongate, flattened, gradually tapered process. Segment IX: dorsum excised to anterior margin, asymmetrical; pleuron protruded caudally. Inferior appendages: shorter than segment IX. Aedeagus: sheath elongate, with small spine at midlength and thick spine at base of apical process; apical process sinuate and black at tip; aedeagus elongate with titillator and two distal lobes.

Female.—Unknown.

Etymology.—Named for black tip of aedeagal sheath.

Holotype.—Male. New Caledonia: Boulari River, 3 Nov. 1958, C. R. Joyce.

Paratypes.—Same data as holotype, 86 ♂. Same locality as holotype, 17 Nov. 1958, 9 ♂.

Diagnosis.—*Paroxyethira nigrispina* males have an elongate aedeagal sheath similar to males of *P. kimminsi* Leader. The apex of the sheath however is distinct.

## Acknowledgments

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# WASP PARASITES OF THE BURDOCK SEED MOTH, *METZNERIA LAPPELLA* ZELLER (GELECHIIDAE): NEW HOST RECORD FOR *BRACON MELLITOR* SAY (HYMENOPTERA: BRACONIDAE)

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*Abstract.*—*Bracon mellitor* parasitizes the burdock seed moth, *Metzneria lappella.* This is a new host record for this wasp, best known as a parasite of the boll weevil, *Anthonomus grandis. Agathis malvacearum,* another wasp parasite of this moth, is newly reported from the Pacific coast of Washington, a westward range extension of 2000 km. We also report a transcontinental North American distribution for the host–parasite association of *M. lappella* with *Hyssopus thymus,* the paramount Nearctic wasp parasite of the European pine shoot moth, *Rhyacionia buoliana.*

*Key Words:* Braconidae, burdock, distribution, Gelechiidae

The burdock seed moth, *Metzneria lappella* Zeller (Lepidoptera: Gelechiidae) eats the seeds of burdock (the Palearctic genus, *Arctium* L. (Compositae)) by excavating in the indehiscent flower head, or bur. Naturalized in North America, this univoltine moth is found wherever common burdock, *A. minus* (Hill) Bernhardi, is established (Purrington 1970). Field collections of burdock burs made in the United States have yielded several wasp species that parasitize *M. lappella* larvae (Juhala 1967, Purrington 1970, 1979, Purrington and Uleman 1972). In this paper, we report a new primary wasp parasite of this moth and record new distributions for two other parasites.

We obtained about 100 burs in Mattapoisett, MA (12-II-86), which yielded 250 *M. lappella* larvae and 7 overwintering prepupal larvae of *Bracon mellitor* Say (Hymenoptera: Braconidae). This was the first record of *B. mellitor* as a parasite of *M. lappella.* Wasp larvae were enclosed in papery silken cocoons inside host excavations within the burs. *Bracon mellitor* is a solitary univoltine ectoparasite of several larval weevils and moths in the Nearctic region (Adams et al. 1969, Cross and Chesnut 1971, Krombein et al. 1979, Cuda and Burke 1983). It is an important parasite of the boll weevil, *Anthonomus grandis* Boheman (Coleoptera: Curculionidae) (Adams et al. 1969, Sturm and Sterling 1986, Pencoe and Phillips 1987).

*Agathis malvacearum* Latreille (= *A. metzneriae* Muesebeck) (Hymenoptera: Braconidae) is an Old World solitary univoltine endoparasitic wasp introduced into the Western Hemisphere, probably with burdock containing *M. lappella.* In the Palearctic, *A. malvacearum* is also found on the moths, *M. carlinella* Stainton (Gelechiidae), *Evetria resinella* L. (Gelechiidae), and *Coleophora otitae* Zeller (Coleophoridae) (Shenefelt 1970). North American distribution records are Quebec, New England, Long Island, and west to North Dakota (Juhala 1967, Krombein et al. 1979). We found *A. malvacearum* on *M. lappella* in burdock collected at Portland, OR (Reed College, 25-XII-85, col. C. B. Purrington), Bellfountain, OR (10-I-86), and Seattle, WA (Pike Place, 6-I-86). The new records extend the wasp's known range by 2000 km westward to the Pacific coast.

Evidently burdock has been present in western Washington since at least the 1930's (Gunther 1973). It arrived in the New World with European settlers in the same way that it has become ubiquitous: its burs are armed with hooked spiny bracts that engage fur and cloth. Although Fyles (1899) speculates that *M. lappella* arrived in Quebec from Europe only late in the 19th century, burdock infested with *M. lappella* and its braconid parasite, *A. malvacearum,* likely became established in North America soon after the first settlements were made along the Atlantic coast. Gross et al. (1980) review the introduction and early distribution of burdock in North America.

We recovered *Hyssopus thymus* Girault (Hymenoptera: Eulophidae), a multivoltine, gregarious, larval ectoparasite from *M. lappella* in burrs obtained at Mattapoisett, MA (12-II-86), Wooster, OH (10-IV-86), and Kent, WA (2-I-86). These new collection records establish a coast-to-coast North American distribution for the *M. lappella–H. thymus* host–parasite association, a relationship first reported from North Dakota (Purrington 1970). According to Syme (1974), *H. thymus* is the most common, widespread, and effective Nearctic parasite of the European pine shoot moth, *Rhyacionia buoliana* (Schiffermüller) (Tortricidae).

We anticipate that wherever burdock becomes established it will have arrived with some members of a small integrated insect community. We predict this community will include the Old World co-immigrants, *M. lappella* and *A. malvacearum,* as well as eclectic elements from native fauna.

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# THE COCKROACH GENUS *MARGATTEA* SHELFORD, WITH A NEW SPECIES FROM THE KRAKATAU ISLANDS, AND REDESCRIPTIONS OF SEVERAL SPECIES FROM THE INDO-PACIFIC REGION (DICTYOPTERA: BLATTARIA: BLATTELLIDAE)

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*Abstract.*—Diagnostic characters for the cockroach genus *Margattea* Shelford are given. *Theganosilpha* Kumar and Princis is synonymized with *Margattea*. ***Margattea paraceylanica*, n. sp.** from the Krakatau Islands is described. The following *Margattea* species are redescribed: *ceylanica* (Saussure), *nimbata* (Shelford) (previously considered a synonym of *ceylanica*), *perspicillaris* (Karny), *anceps* (Krauss), *contingens* (Walker) [= *humeralis* (Walker)], and *longealata* (Brunner). A key to the above males is provided. *Symploce obtusifrons* (Walker) (sp. incertae sedis) is transferred to *Margattea*. The following species of *Margattea* are transferred to the genus *Balta* Tepper: *aurea* Hanitsch, *setifera* (Hanitsch), *parvula* (Bolívar), *crassivenosa* (Bolívar), and *longicercata* (Bolívar). The position of the male's genital hook and rotation of the ootheca in subfamily placement (Pseudophyllodromiinae or Blattellinae) is discussed.

*Key Words:* Cockroaches, Blattellidae, taxonomy, Krakatau Islands

Princis (1969: 862, 1971: 1162) listed 44 species of *Margattea* Shelford. It is a widely distributed genus with species occurring in Asia, Indonesia, Malaysia, South Pacific, and Africa. This paper is a result of my attempt to identify a few specimens of *Margattea* collected in the Krakatau Islands and Australia. After reading the many species descriptions it was evident that the genus needed revision and that the various taxa should be redescribed with particular emphasis on male genitalia. In the original descriptions of known species, 12 were based on both sexes, 17 on males, and 15 on females only. Even when males were described, a number of characters which are known to be important today (e.g. type of front femur, whether or not the tarsal claws are toothed, whether or not the male has a tergal gland, and the shapes of the male genital phallomeres were not mentioned). Identification of females, when only that sex is known, is difficult unless the specimens are topotypic and the species have distinctive color patterns. Based on descriptions a number of species of *Margattea* belong in another genus. For example, I have examined the types of the following species and they all belong in the genus *Balta* Tepper: *Margattea aurea* Hanitsch (HDEO), *M. setifera* Hanitsch (NRSS), *M. parvula* Bolívar (BMNH), *M. crassivenosa* Bolívar (BMNH), and *M. longicercata* Bolívar (BMNH).

The Krakatau specimens were collected by personnel from institutions in Australia, Indonesia, and the United Kingdom during 1984 and 1985 expeditions (Thornton and Rosengren, in press). Thirteen species of cockroaches were taken and I will report on these elsewhere. Only one species of *Margattea* was collected and it did not agree with the four species of the genus previously reported from these islands; I am describing it as new. I will present the diagnostic characters of the genus and redescribe the following taxa that have been recorded from the Krakataus by others: *M. ceylanica* (Saussure), *M. contingens* (Walker) [= *M. humeralis* (Walker)], *M. anceps* (Krauss), and *M. nimbata* (Shelford). *Kuchinga* Hebard has been considered a junior synonym of *Margattea,* and I have concluded that *Theganosilpha* Kumar and Princis also is a junior synonym and therefore will redescribe their type species [*Kuchinga longealata* (Brunner) and *Theganosilpha perspicillaris* (Karny)].

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(ANSP)—Academy of Natural Sciences of Philadelphia, PA, U.S.A.; Mr. Donald Azuma.
(BMNH)—British Museum (Natural History), London, England; Mrs. Judith Marshall.
(BPBM)—Bernice P. Bishop Museum, Honolulu, HI, U.S.A.; Mr. Gordon M. Nishida.
(DEIG)—Deutsches Entomologisches Institut, Eberswald, Germany; Dr. G. Petersen.
(HDEO)—Hope Department of Entomology, University Museum, Oxford, England; Dr. George C. McGavin.
(MCZH)—Museum of Comparative Zoology, Harvard University, Cambridge, MA, U.S.A.
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(RNHL)—Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands; Dr. Jan van Tol.
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### Genus *Margattea* Shelford

*Margattea* Shelford 1911:155. Type species, by monotypy: *Blatta ceylanica* Saussure, Rehn 1931: 302; Bey-Bienko 1938: 121; 1950: 145; Princis 1969: 862.

*Kuchinga* Hebard 1929:39, 41. Type species, by selection: *Phyllodromia longealata* Brunner; Hanitsch 1931b: 392 (synonymized with *Margattea*); Bey-Bienko 1938: 121 (synonymized with *Margattea*).

*Theganosilpha* Kumar and Princis 1978: 33; Asahina 1979: 114, 119. Type species by monotypy: *Theganopteryx perspicillaris* Karny. New Synonymy.

Diagnosis.—The following characterization is based on the species mentioned earlier as well as a study of more than 25 described and undescribed species which I plan to present elsewhere: Third and fourth maxillary palpal segments usually longer than the fifth (Fig. 40). Tegmina and wings fully developed or variably reduced, hind wings rarely absent; if reduced, hind wings are generally shorter than the tegmina and may be vestigial; if fully developed, hind wings have the discoidal and median veins simple, subcosta and most costal veins clubbed or thickened distad, cubitus vein essentially straight or weakly curved, with 1–4 complete (rarely 0 branches in reduced wings) and no incomplete branches, apical triangle small (Figs. 6, 13). Abdominal terga unspecialized, or with a group of setae near the posteromedial margin of eighth tergum (Figs. 24, 28); this specialization may be hidden under the seventh tergum. Anteroventral margin of front femur Type $B_2$ or $B_3$ (with 1 to 4 proximal spines) (Fig. 34) (both types may occur in the same species, differing between the sexes), rarely Type $C_2$; all 4 proximal tarsomeres with pulvilli, tarsal claws symmetrical with inner margins generally denticulate (Figs. 7, 20, 32; the serrations often subobsolete and sometimes only seen at high magnification of a compound microscope), arolia present. Supra-anal plate usually relatively short, transverse, right and left male paraprocts similar, relatively simple plates (Figs. 8, 16). Male subgenital plate symmetrical or subsymmetrical styles simple, cylindrical, generally similar (Figs. 1, 29, 44); some species with a stylelike process at the base of each style giving the appearance of having 4 rather than 2 styles (Figs. 51, 69, 72). Male genitalia with hooklike phallomere on the right side; median sclerite may have an associated sclerite sometimes with setal brushes (Figs. 1, 26, 29, 69).

Comments.—The principal diagnostic characters used by Kumar and Princis to distinguish *Theganosilpha* from *Theganopteryx* were hind wings reduced in both sexes, eighth tergum of male weakly specialized, anteroventral margin of front femur Type $B_3$ (some large proximal spines followed by a row of piliform spinules and terminating in 3 distal spines), inner margins of tarsal claws finely denticulate. Asahina (1979: 119) accepted *Theganosilpha* as a valid genus and correctly pointed out that it was closer to *Margattea* than to *Theganopteryx*.

Rehn (1931) stated that the front femur of *M. ceylanica* was Type $B_2$ and that the tarsal claws were equal with internal margins unspecialized (i.e. not denticulate). Bey-Bienko (1938: 121) believed that the tarsal claws of *M. ceylanica* and *M. longealata* are equal and unspecialized, but later (Bey-Bienko 1958: 587) correctly stated that the former has barely visible notched tarsal claws. The claws of *M. longealata* also have subobsolete serrations. Asahina (1979: 119) pointed out that since some species of *Margattea* have toothed tarsal claws, this character cannot be used to distinguish it from *Theganosilpha*. The size of the denticles may be so small that they cannot be seen at the magnifications usually used in examining pinned specimens with a dissecting microscope. If slides are prepared and the claws are examined at high magnification with a compound microscope, the minute teeth, or their remnants (Figs. 7, 20) can be seen.

The male abdominal terga of *M. ceylanica* and *M. longealata* are unspecialized. The male of *Theganosilpha perspicillaris* has a setal tuft on the eighth tergum. There are many examples of genera in which the males of a genus have or lack abdominal tergal glands (used in courtship behavior), and in those species that have them the specializations may be found on one or more segments. For example, species of *Blattella* may have glands on T7 only, or on T7 and T8, and the morphology of the glands may differ considerably between different species (Roth 1985a). In species of *Parcoblatta* Hebard, the males have glands on T1 only (6 spp.), T1 and T2 (4 spp.), or they are absent (2 spp.) (Hebard 1917).

Asahina (1979: 119) separated *Theganosilpha* from *Margattea* as follows: In *Theganosilpha* the front femur is Type $B_3$, the tegmina are narrowed apically, somewhat nail shaped, rather coriaceous, and the hind wings are rudimentary but sometimes one half the length of the tegmina. In *Margattea* the front femur is Type $B_2$, the tegmina are not narrowed apically or nail shaped, and it and the hind wing are fully developed. Hebard (1929: 4) pointed out that wing reduction often is an unreliable generic character (unless correlated with other more stable features), and the armament on the front femur also is subject to individual variation. Kumar and Princis (1978: 33) described the hind wings in both sexes of *T. perspicillaris* as reduced to small narrow lappets about half the length of the tegmina. The male lectotype and two male paralectotypes of this species actually have vestigial wings distinctly less than half the length of the tegmina. The hind wings of a male *T. perspicillaris* (fig. 25 *in* Asahina 1979) are more than half the length of the tegmina and their veins are well developed.

It is possible for a genus to have more than one type of front femur. Species of *Balta* may have Type B or C (Hebard 1943: 39). Bey-Bienko (1938: 121) claimed that *Margattea inermis* Bey-Bienko is aberrant in having a Type $C_2$ rather than Type B femur. *Margattea hemiptera* Bey-Bienko (Bey-Bienko 1958) and *Margattea elongata* Kumar (Kumar 1975: 105) have reduced tegmina and wings and Type $B_2$ front femurs. I have examined specimens of *Theganosilpha ogatai* Asahina and *Theganosilpha satsumana* Asahina (identified by Asahina) and in both species the males have Type $B_2$ and the females Type $B_3$ femurs. There is no correlation between Type $B_3$ femurs and wing reduction, and Type $B_2$ femurs with fully developed organs of flight.

The difference of 1 distal spine on the anteroventral margin of the front femur (Type $B_2$ vs. Type $B_3$), the variable reduction of tegmina and wings, and the presence or absence of a male tergal gland cannot be used to distinguish between *Margattea* and *Theganosilpha,* and I am synonymizing the latter genus. The diagnostic characters for the genus *Margattina* Bey-Bienko are so similar to those of *Margattea* (Bey-Bienko 1958: 587) that I believe the former genus (known only from the type species *Margattina trispina* Bey-Bienko, a single male from China) should be reevaluated.

### SUBFAMILY PLACEMENT OF *MARGATTEA*

The genitalia of male cockroaches are strongly asymmetrical and one of the more conspicuous structures is a hooklike phallomere (Fig. 29) although in some species (Blaberidae) it may be greatly reduced. According to McKittrick (1964) in the Blattellidae the hook is on the left side in the Blattellinae, Ectobiinae, and Nyctiborinae, or on the right in the Plectopterinae (= Pseudophyllodromiinae in Vickery and Kevan's 1983, classification). McKittrick also claimed that the females of Blattellinae, Ectobiinae, and Nyctiborinae rotate their oothecae during oviposition, whereas the Plectopterinae do not. This concept holds for a large number of species but Brown (1975) found that *Ectobius panzeri* Stephens has the male genital hook on the right side although the female rotates its ootheca (Brown 1973). Bohn (1987) found that the male of *Phyllodromica* (*Lobolampra*) *montana* Chopard and several other species of the "*montana*-group" of *Phyllodromica* (Ectobiinae) show a similar reversal of the right-left asymmetry in male genitalia and have the hook on the right whereas some other species of the genus have the hook on the left. Although Bohn did not mention oviposition behavior of *P. montana* in his paper, he (personal communication) was "convinced" that it rotates its ootheca and that it and *Ectobius panzeri* are true Ectobiinae, all of which rotate their oothecae.

In *Margattea* the male's genital hook is on the right side which in McKittrick's system places it in the Plectopterinae. However, 2 females of *Margattea nimbata* were carrying oothecae in the rotated position (Fig. 25) a behavior which is characteristic of the Blattellinae. As Bohn (1987: 303) pointed out, it is not sufficient to use the position of the genital hook in placing blattellids in their respective subfamilies. He also claimed that symmetry reversal has occurred several times independently during the evolution of the Blattaria and that it is possible there are species of Blattellinae with reversed symmetry as those found in the Ectobiinae. Bohn concluded that other characteristics such as oothecal rotation, and especially structure of the phallomeric sclerites be considered.

Since the position of the male's genital hook cannot always be used to distinguish Plectopterinae from Blattellinae, oothecal rotation or its absence appears to be the best discriminating character, and I used it to place a number of Blattellidae into these 2 subfamilies (Roth 1968a, 1971: 134). Thus *M. nimbata,* which rotates its ootheca, belongs in the Blattellinae even though the genital hook is on the right side. But the problem here is more complex. The oviposition behavior of the species other than *nimbata* is not known. Three females of *Margattea longealata* (Brunner) were carrying oothecae whose keels were directed dorsad (i.e. non-rotated) (Fig. 62). It is possible that these specimens were collected before they could rotate their oothecae prior to depositing them. However, the ootheca is distinctly different in morphology from that of *nimbata.* It is particularly unusual in being wider than high and strongly resembles the oothecae of *Lophoblatta brevis* Rehn and *Lophoblatta arlei* Albuquerque from South America (see figs. 1–6 *in* Roth 1968b). These are the only known members of the Plectopterinae that carry their oothecae with their keels dorsad (i.e. non-rotated) until the eggs hatch; other species in this subfamily drop the non-rotated oothecae shortly after it is formed. One ootheca of *M. longealata* (KOH treated) lacked calcium oxalate crystals. The oothecae of *L. brevis* and *L. arlei* have relatively few calcium oxalate crystals, but egg cases in other species in the Plectopterinae have large amounts of calcium oxalate crystals.

The amount of calcium oxalate in cockroach oothecae decreased during the evolution of ovoviviparity and viviparity in the Blaberoidea. Oothecae of the Blattellinae usually have large amounts of calcium oxalate crystals but the amount of this compound varies from dense to sparse to absent in species of *Blattella,* all of which carry their oothecae externally in the rotated position until the eggs hatch (Roth 1968a). Species of the African blattellid genus *Stayella* Roth (Roth 1984) have an ootheca that is typical of species of *Blattella,* but it is retracted and carried internally until the eggs hatch (Roth 1982). The egg cases of *Stayella* lack calcium oxalate as do species of Blaberidae, all of which incubate their eggs internally.

The oothecae of *M. longealata* are somewhat transparent in the specimens studied and their eggs are undeveloped (the eggs from one of the oothecae were removed and cleared and showed no embryonic development). It is possible that *M. longealata* carries its ootheca in the vertical position for the entire gestation period, as in *Lophoblatta,* but the 3 females reported here were collected shortly after their oothecae were formed and therefore their eggs show no development. It is probable that *Margattea contingens* (Walker) has an ootheca similar to that of *longealata* because the male and female genitalia of these 2 taxa are so much alike (Figs. 51, 57–59, 61, 63, 68–70). The male genitalia (particularly the left and right phallomeres) of *M. longealata* and *M. contingens* differ considerably from those of other species in the genus. Perhaps these two species should be placed in a separate genus; if this is done Hebard's *Kuchinga* (type species, *longealata*) would be resurrected. For the present I am placing them in a species group of *Margattea.*

## SPECIES GROUPS OF *MARGATTEA*

I have examined about 25 described species of *Margattea* and about 10 taxa that apparently are new. Thus far my study indicates that the genus can be arranged in seven species groups. The seven species discussed in this paper belong to 3 groups as follows (other species in the groups will be presented elsewhere):

*Ceylanica* species group.—Eighth abdominal tergum unspecialized. Accessory stylelike structures near the base of the styles absent (Fig. 1). Tegmina and wings fully developed. Front femur Type $B_2$. Species: *ceylanica.*

*Perspicillaris* species group.—Eighth abdominal tergum specialized (Figs. 9, 24, 28, 43). Interstylar region may be simply a continuation of the lateral margins of the plate (Figs. 23, 44), or there is a small plate sometimes bearing small dark spines (Fig. 29). Accessory stylelike structures absent (Figs. 18, 29). Tegmina and wings fully developed or variably reduced, the wings sometimes vestigial. Front femur Type $B_2$ or $B_3$. Species: *perspicillaris, nimbata, paraceylanica, anceps.* This is the largest group and contains at least an additional twelve species.

*Contingens* species group.—Eighth abdominal tergum unspecialized. Lateral corners of subgenital plate produced having the appearance of styles (accessory stylelike structures; Figs. 55, 56). Male genital phallomeres: hook portion of right phallomere, slender, elongate, strongly curved; median phallomere needlelike, accessory median phallomere absent; left phallomere roundly bulbous basally, relatively simple (Figs. 51, 57–59) (cp. the differences in the taxa belonging to the other 2 species groups). Tegmina and wings fully developed. Front femur Type $B_2$. Species: *contingens, longealata.*

## KEY TO SOME MALES OF INDO-PACIFIC *MARGATTEA**

1. Eighth abdominal segment without a tergal gland .................................... 2
– Eighth abdominal segment with a tergal gland .................................... 4
2. Subgenital plate with lateral corners produced giving the appearance of accessory stylelike structures (Figs. 51, 55, 56, 69) ............ 3
– Lateral corners of subgenital plate rounded, not stylelike (Fig. 1) .................... *ceylanica*
3. Head brown with a yellowish orange band between antennal sockets (Fig. 65). Pronotal disk with a broad dark brown macula (Fig. 64) *longealata*
– Head with an orangish macula on vertex between the antennal sockets blending into the rest of the lighter face (Fig. 47). Pronotal disk light brown without distinct markings (Fig. 53) .................................. *contingens*
4. Interstylar region a subrectangular plate with short robust spines on posterior margin (Fig. 29). Front femur Type $B_3$ (Fig. 34). Wings shorter than the tegmina, sometimes vestigial ................................ *perspicillaris*
– Interstylar region not as above. Front femur Type $B_2$. Tegmina and wings fully and equally developed ............................... 5
5. Tegmina with a dark brown macula on basal region (Fig. 41), sometimes extending the full length of the wing cover ............... *anceps*
– Tegmina without dark markings ............ 6
6. Apex of median genital phallomere terminating in a pair of heavy spinelike structures (Figs. 18, 23, 26) ......................... *nimbata*
– Apex of median genital phallomere slender, acute (Fig. 10) .................. *paraceylanica*

## DESCRIPTIONS OF SPECIES OF *MARGATTEA*

### ***Margattea ceylanica*** **(Saussure)**
Figs. 1–7

*Blatta ceylanica* Saussure 1868: 355 (♀); 1869: 247; Walker 1871: 20.

*Allacta ceylanica* (Saussure): Kirby 1904: 100.

*Phyllodromia ceylanica* (Saussure): Shelford 1908b: 12; Dammerman 1948: 483.

*Margattea ceylanica* (Saussure): Shelford, 1911: 155; Rehn 1931: 302, fig. 1; Hanitsch 1933a: 232; 1933b: 310; 1934: 118; 1936: 392; Bruijning 1947: 221; 1948: 62; Bey-Bienko 1957: 899; Princis 1969: 862 (references to generic combinations and records; incorrectly included *M. nimbata* as a synonym); Asahina 1979: figs. 69–71.

Material examined.—Sri Lanka. (MNHG): holotype female of *Blatta ceylanica,* Peradenia, "Ceylan." (ANSP): The following specimens were determined by Hebard as *M. ceylanica* (Sauss.) and many were labelled topotypes: Belihuloya, 1 ♂ (terminalia slide 398), 1.ix.1928; Bibile Estate, 1

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* Includes only males discussed in this paper. I have seen specimens only of *nimbata* and *paraceylanica* from the Krakataus. The earlier records of *ceylanica, contingens,* and *anceps* from these islands are questionable.

Figs. 1–7. *Margattea ceylanica* (Saussure) from Sri Lanka. 1, 3–6, males from Udahamulla, and 7, from Battaramulla. 2, female from Labugama: 1, subgenital plate and genitalia (dorsal); 2, supraanal plate and genitalia (ventral); 3, distal ends of median, accessory median, and hooklike right genital phallomeres; 4, pronotum; 5, supraanal plate and paraprocts; 6, hind wing; 7, tarsal claws. Abbreviations: a, left phallomere; b, median phallomere; c, accessory median phallomere; d, hooklike right phallomere; e, style; f, supraanal plate; g, paraproct; h, intercalary sclerite; i, first valvifer. Scales (mm): 1, 2, 0.5; 3, 0.25; 4, 1.0; 5, 0.5; 6, 2.0; 7, 0.15.

♂, 26.vii.1929; Wellaway, 1 ♂, 28.iv.1931; Rakwana, 1 ♀, 3.v.1929; Horawupotana, 1 ♂, 1 ♀, 13.x.1924; Labugama, 1 ♂, 2 ♀ (1 with genitalia slide 404), 15–18. viii.1932; Woodside, Urugalla, 2 ♂, 22.iv.1924; Battaramulla, W.P., 1 ♂, 20.v.1931; Udahamulla, W.P., 1 ♂ (terminalia slide 399), ix.1926.

Male.—Interocular space decidedly less than distance between antennal sockets. Tegmina and wings fully developed; hind wing with costal veins clubbed, cubitus vein with 2 complete and 0 incomplete branches, apical triangle small (Fig. 6). Pronotum suboval (Fig. 4). Abdominal terga unspecialized. Anteroventral margin of front femur Type $B_2$ (with 3 or 4 large spines on proximal half); tarsal claws weakly serrated (Fig. 7; serrations sometimes difficult to see under binocular microscope). Supraanal plate transverse, hind margin trigonal, apex sometimes weakly indented; paraprocts dissimilar (Fig. 5). Subgenital plate almost symmetrical, styles similar, cylindrical, interstylar margin weakly convex (Fig. 1). Genitalia as in Figs. 1 and 3; hooklike right phallomere with a small apical spine; apex of median phallomere enlarged, the swollen portion terminating in a transparent filament; apex of accessory median sclerite narrow and slightly curved; left phallomere with spinelike processes.

Coloration.—Light brown. Vertex with dark brown band connecting eyes at top of head, occiput pale, whitish band along eye margins between tops of antennal sockets followed by a light transverse band, below this a pair of light brown spots. Pronotal disk with brown pattern as in Fig. 4, the remainder of pronotum hyaline. Tegmina hyaline without markings. Abdominal terga infuscated, with light brown medial areas. Abdominal sterna light brown with small dark maculae laterally, and some infuscation on lateral borders. Legs pale without dark markings. The markings are variable; the pronotal pattern may be intense or subobsolete, with gradations in between; also the amount of tergal infuscation and the size of the sternal maculae varies.

Female.—Supraanal plate transverse, hind margin weakly convex, medially weakly concave (Fig. 2). Genitalia as in Fig. 2; intercalary sclerites greatly reduced.

Measurements (mm) (♀ in parentheses). Length, 8.0–9.2 (7.8–8.9); pronotum length × width, 2.1–2.2 × 2.8–3.2 (2.1–2.3 × 3.0–3.2); tegmen length, 9.1–10.5 (8.7–10.1).

Comments.—This species was not collected on the 1984/85 Krakatau expeditions. Dammerman (1948: 483), and Bruijning (1948: 62) recorded it from Krakatau, the latter from a single female collected in May, 1908. Princis (1969: 862) listed the species from Ceylon, Java, Borneo, and Krakatau (probably based on the above two authors). Most likely the Krakatau records were misidentifications and referred to *M. nimbata* (see remarks under that species), or *M. paraceylanica*.

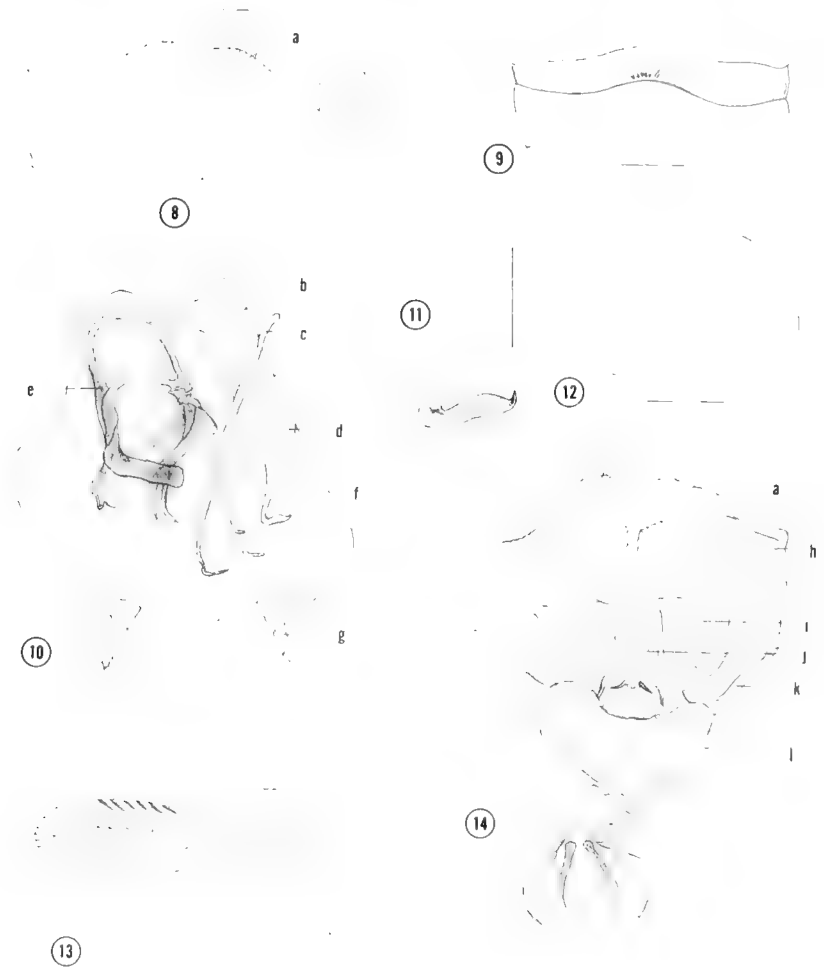
Asahina (1979) illustrated the terminal abdominal segments and right hooklike genital phallomere (which he incorrectly labelled the left phallosome) (his figs. 69, 70) of a Sri Lankan specimen which he determined as *M. ceylanica* with a query. His drawings of these structures agree with the specimens of *ceylanica* which I have illustrated here.

### *Margattea paraceylanica* Roth
NEW SPECIES
Figs. 8–14

Holotype.—Male, Rakata, Krakatau Islands, 200 m, s. face, 24.viii.1985, Zool. Exp. Krakataus.

Paratypes.—Krakatau Islands: Rakata, Zwarte Hoek, 850 ft., ridge, water trap, 1 ♂ (terminalia slide no. 3), 1984; 6.09S 105.25E, under rocks, 1 (abdomen missing), 1 ♀ (genitalia slide no. 4), 6.ix.1984; Rakata, s. face, 200 m, 1 ♀, 400 m, 1 nymph, 24.viii.1985; Panjang, 6.05S 105.28E, ex litter, 1 ♀, 14.ix.1984, 1 ♀, beating, 20.ix.1984; Sertung, 6.04S 105.24–25E, spit, transition zone, sweep, 1 ♂, 18.viii.1985. [All specimens were collected on the 1984 and 1985 expeditions to the Krakatau Islands. The holotype and some of the paratypes are deposited in the Zoological Museum, Bogor, W. Java. Some specimens will be kept at (TUVA).]

Male.—Pronotum subelliptical (Fig. 12). Tegmina and wings fully developed extending beyond end of abdomen. Hind wing with costal veins thickened distad, cubitus with 4 complete and 0 incomplete branches, apical triangle very small (Fig. 13). Anteroventral margin of front femur Type $B_2$ (with 3 or 4 large proximal spines); tarsal claws symmetrical, minutely serrated, pulvilli on 4 proximal tarsomeres, arolia present. Eighth abdominal tergum with a posteromedial tuft of setae, hind margin concave (Fig. 9). Supraanal plate transverse, hind



Figs. 8–14. *Margattea paraceylanica* Roth, paratypes from Rakata. 8–13, male: 8, supraanal plate and paraprocts (ventral); 9, abdominal terga 8 and 9; 10, subgenital plate and genitalia (dorsal); 11, hooklike right phallomere; 12, pronotum; 13, hind wing; 14, female, supraanal plate and genitalia (ventral). Abbreviations: a, supraanal plate; b, accessory median phallomere; c, median phallomere; d, right phallomere; e, left phallomere; f, subgenital plate; g, style; h, paraproct; i, intercalary sclerite; j, ovipositor valve; k, paratergite; l, first valvifer. Scales (mm): 8–10, 0.5; 11, 0.15; 12, 1.0; 13, 2.0; 14, 0.5.

margin weakly concave medially; right and left paraprocts weakly defined, similar (Fig. 8). Subgenital plate weakly asymmetrical, styles similar, cylindrical, interstylar margin weakly convex (Fig. 10). Genitalia as in Fig. 10; apex of hooklike right phallomere acute, without an apical or preapical spine; the tip looks like a spine but it is not articulated (Fig. 11); median phallomere slender throughout; associated median phallomere with a small preapical branch; left phallomere with spinelike processes.

Coloration (specimens originally preserved in alcohol, then pinned and dried).—

Light brown. Head with dark band on vertex extending as faint stripes on occiput. Pronotal disk with light symmetrical spots and lines (variable in intensity), surrounding regions mostly hyaline (Fig. 12). Tegmina hyaline, humeral region colorless, remainder light brown; hind wings appear colorless but when mounted on a white card the apical region of the anterior field has a faint yellowish tinge.

Female.—Supraanal plate (Fig. 14) similar to that of the male (Fig. 8). Subgenital plate extends well beyond hind margin of supraanal plate. Genitalia as in Fig. 14; intercalary sclerites very large dark plates that extend laterally well beyond ovipositor valves, first valvifer slender rods without swellings.

Measurements (mm) (♀ in parentheses). Length, 6.8–8.0 (7.3–8.5); pronotum length × width, 2.0–2.1 × 2.7–3.0 (2.2 × 2.9–3.0); tegmen length, 7.2–8.6 (7.3–7.9).

Comments.—The male genital phallomeres and female genitalia clearly show a close relationship to *ceylanica*. Although the subgenital plate and styles are similar in both *paraceylanica* and *ceylanica*, the former has a tergal gland on T8 which is lacking in the latter. The female genitalia of both taxa are distinctly different. It is likely that *paraceylanica* occurs on other Indonesian islands.

## *Margattea nimbata* (Shelford)

Figs. 15–26

*Phyllodromia nimbata* Shelford 1907b: 31 (♂ ♀); 1908b: 13; Hanitsch 1915: 57; 1923b: 410.

*Margattea nimbata* (Shelford): Hanitsch 1928: 23; 1929a: 13; 1931b: 392; 1932a: 5; 1933b: 310 (incorrectly synonymized with *ceylanica*); Bruijning 1947: 221; 1948: 62; Princis 1969: 863 [Bruijning and Princis accepted Hanitsch's synonymy].

*Kuchinga nimbata* (Shelford): Hebard 1929: 42.

Material examined.—Lectotype (here designated). Male (terminalia slide 200), Kuching, N.W. Borneo [Sarawak], pres. 1905 by Sarawak Museum, 15.xii.1898. Type Orth. 89 1/4 in (HDEO). Paralectotypes. Sarawak. (HDEO): 2 ♀ (genitalia slides 201 and 203), same locality as lectotype, Dyak coll. pres. 1900 by R. Shelford, 25.1.1900 and 27.vii.1900, Type Orth. 89 3/4 and 89 4/4.

Additional material.—Krakatau. (RNHL): 1 ♂ (terminalia slide 139) 1 ♀ (with rotated ootheca, keel to right, Fig. 25) (det. as *Margattea ceylanica* by Hanitsch); 1 ♀, v.1908, E. Jacobson (labelled *M. ceylanica*).

Australia (Northern Territory). (BPBM): Holmes Jungle, Palm Cr., 15 km NE of Darwin, 5 m, 2 ♂ (1 with terminalia slide 468), 1 (abdomen missing), light trap, 11.iii.1961, 1 ♂, 14.iii.1961, J. L. and M. Gressitt.

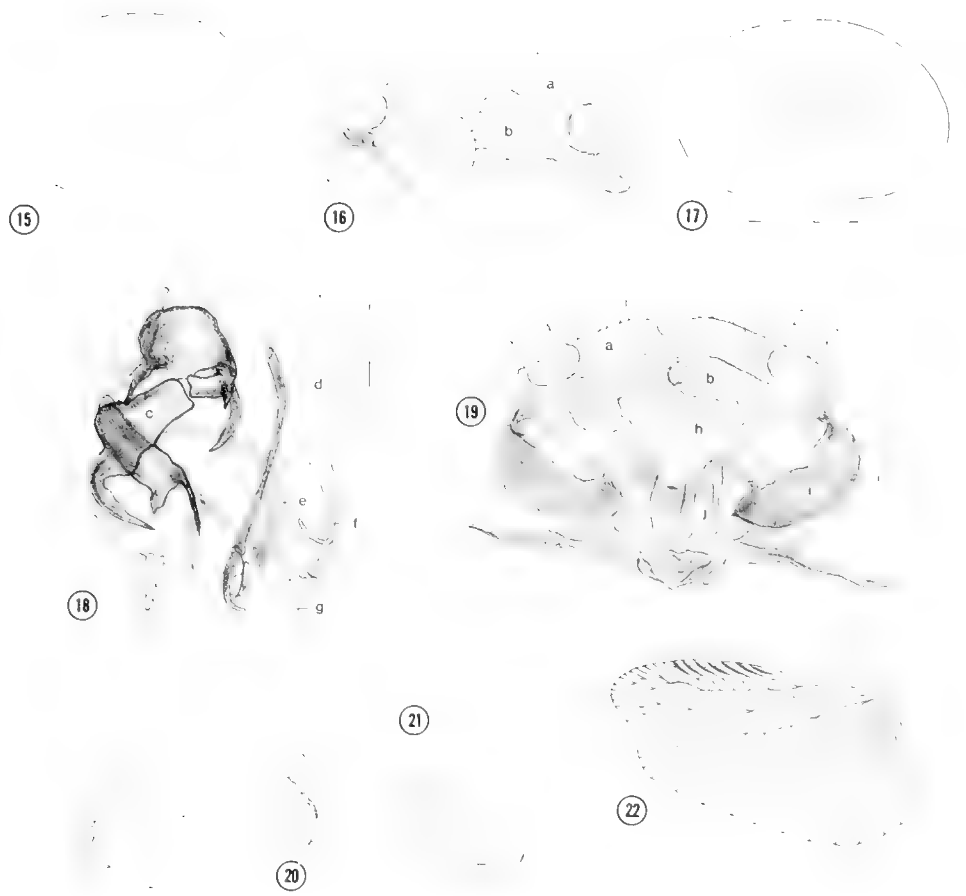
Kei Island. (RNHL): 3 ♀, 1922, H. C. Siebers (labelled *Phyllodromia nimbata* Shelf., by Hanitsch).

Christmas Island (Indian Ocean). (ANIC): National Park, 1 ♂ (terminalia slide 210), 2 ♀, 3 nymphs, x.1983, L. Hill [ANPWS].

Thailand. (ZILS): 30 km south of Pak Thong Chai, 2 ♂, 1 ♀ (reared from ♀ taken in a dry stream bed) (det. as *M. ceylanica* by Princis), 13.iv.1967, 1 ♂, 14.iv.1967, 2 ♀ (on shrubbery at night), 26.iv.1967 (det. as *M. ceylanica* by Princis), 1 ♂ (reared from ♀ taken on shrubbery at night) [det. as *Margattea punctulata* (Brunner) by Princis], 26.iv.1967, L. M. Roth.

Sarawak. (ANSP): Kapit, 1 ♀ (terminalia slide 405), 9.vii.1910, Wm. Beebe [reported as *Kuchinga nimbata* (Shelford), by Hebard, 1929:42]. (NRSS): Medan, 5 ♂, 1 (abdomen missing), Mjoeberg (labelled *Phyllodromia* or *Margattea nimbata* Shelf., by Hanitsch); Tjinta Radja, 1 ♀, Mjoeberg (labelled *Phyllodromia nimbata* Shelf., by Hanitsch).

Borneo (Kalimantan). (NRSS): Tandjong, Redeb, O. Borneo, 3 ♂ (1 with terminalia slide 67) (labelled *Margattea ceylanica* Sauss., by Hanitsch), 2 ♀ [1 with rotated ootheca and labelled *Margattea cey-*

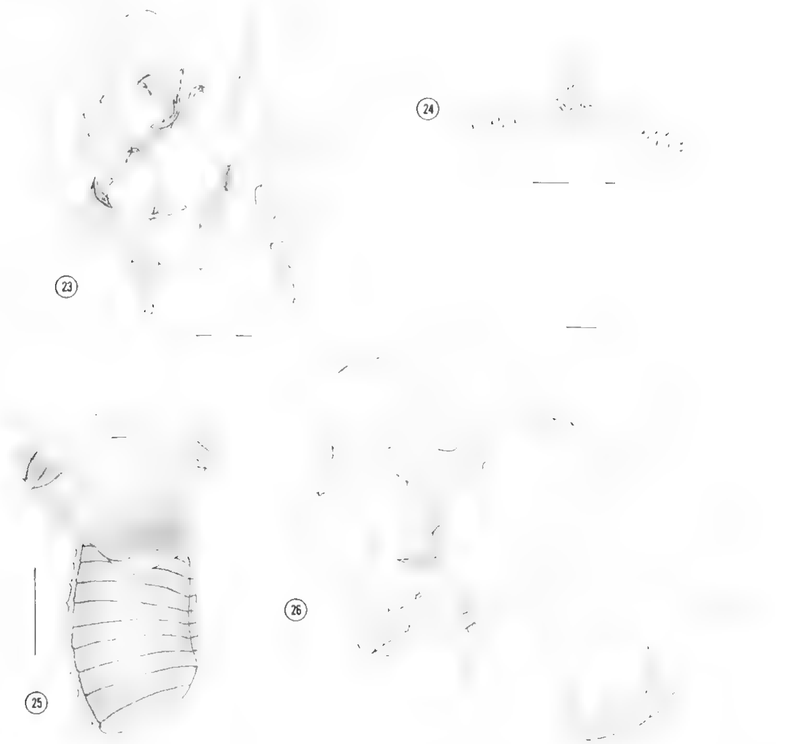


Figs. 15–22. *Margattea nimbata* (Shelford). 15, 16, 18, 20, 21, male lectotype, 17, 19, female paralectotype, 22, female from Kapit, Sarawak: 15, pronotum; 16, supraanal plate and paraprocts (ventral); 17, pronotum; 18, subgenital plate and genitalia (dorsal); 19, supraanal plate and genitalia (ventral); 20, tarsal claws and arolium; 21, right phallomere; 22, hind wing. Abbreviations: a, supraanal plate; b, paraproct; c, left phallomere; d, median phallomere; e, accessory median phallomere; f, right phallomere; g, style; h, intercalary sclerite; i, paratergite; j, ovipositor valve. Scales (mm): 15, 1.0; 16, 0.5; 17, 1.0; 18, 19, 0.5; 20, 21, 0.15; 22, 2.0.

*lanica* Sauss. (= *M. nimbata* Shelf.), by Hanitsch]. (ZILS): Pelawan besar, 1 ♀ (det. as *M. ceylanica* by Princis), vi.1937, Mrs. M. E. Walsh.

Java. (RNHL): Ardja Sari, Preanger, 1 ♀ (det. as *M. nimbata* by Bruijning 1949).

Male.—Interocular space less than distance between antennal sockets. Pronotum subelliptical (Fig. 15). Tegmina and wings fully developed, extending beyond end of abdomen. Hind wing with subcosta and costal veins clubbed distad, discoidal and median veins straight, unbranched; cubitus vein straight with 2–5 complete and 0 incomplete branches, apical triangle small (Fig. 22). Front femur Type $B_2$ (with 3–5 large proximal spines); pulvilli present on 4 proximal tarsomeres, tarsal claws symmetrical with subobsolete denticles on ventral margins (Fig. 20), arolia present. Eighth abdominal tergum medially concavely arched and bearing posteromedially a group of setae (tergum 8 in the lectotype is damaged, but the specialization is visible in other males) (Fig. 24). Supraanal plate transverse, convexly rounded, apex of hind margin weakly



Figs. 23–26. *Margattea nimbata* (Shelford). 23–25, from Krakatau: 23, male subgenital plate and genitalia (dorsal); 24, male, setal modification on eighth abdominal tergum; 25, female with rotated ootheca attached to terminal segments (ventral); 26, male from Northern Territory of Australia, genital phallomeres (dorsal). Scales (mm): 23, 0.5; 24, 0.25; 25, 1.0; 26, 0.25.

excavated, reaching to about hind margin of subgenital plate; right and left paraprocts similar (Fig. 16). Subgenital plate subsymmetrical, styles similar, cylindrical, interstylar margin weakly convex, accessory stylelike structures absent (Figs. 18, 23). Genitalia as in Figs. 18, 21, 23, 26; left phallomere large and complex with spinelike processes; apex of median phallomere with a pair of spinelike structures (visible in pinned specimens), accessory median sclerite present; hooklike right phallomere without a subapical or apical spine.

Coloration.—Yellowish or light brown. Head with pale occiput, a reddish transverse band on vertex, sometimes with a lighter brown interocellar band. Pronotal disk yellowish brown with symmetrical reddish or light brown dots and lines, surrounding area mostly hyaline (Fig. 15). Tegmina hyaline, pale brown; hind wing with clubbed region of costal veins dark, remainder essentially not infuscated (Fig. 22). Abdominal terga pale with narrow dark brown transverse bands along anterior margins of segments that do not reach lateral bands, narrow posterior segmental bands connect with broad lateral infuscation; supraanal plate with a pair of dark brown spots on posterior half separated by a narrow whitish spot behind the concave apex, basal half of segment yellowish brown (Fig. 16). Abdominal sterna pale with broad lateral dark brown borders that become narrower on posterior segments; subgenital plate pale except for narrow dark interstylar margin. Cerci with basolateral area of segment 8 and most of segment 9 dark brown, remainder (including 3 terminal segments) pale (cercal color varies and the dark areas may be practically absent).

Female.—Supraanal plate transverse, hind margin with a distinct narrow, concave excavation (Fig. 19). Genitalia as in Fig. 19; sclerites very darkly pigmented, paratergites very wide. Pronotal disk markings similar to, or more pronounced than in male (Fig. 17). Ootheca as in Fig. 25.

Measurements (mm) (♀ in parentheses). Length, 7.2–9.0 (8.0–9.6); pronotum length × width, 2.0–2.5 × 2.5–3.3 (2.2–2.5 × 3.0–3.4); tegmen length, 7.7–10.3 (7.3–10.1).

Comments.—Hebard (1929: 42) suggested that *nimbata* may be a pale form of *obtusifrons* Walker, but Hanitsch (1931b: 392) was correct in stating that these 2 species are distinct. The female genitalia of *nimbata* (Fig. 19) and *obtusifrons* (fig. 14L *in* Roth 1985b) differ. I have reexamined the type female of *Blatta obtusifrons* which has been placed in ?*Kuchinga* (Hebard 1929), *Symploce* (Princis 1969: 9) and sp. incertae sedis (Roth 1985b: 156). The female's front legs are missing but the tarsal claws on 2 other intact legs are minutely toothed. The male's front femur is Type $B_3$ [with 5 large proximal spines, then 2 short heavy spines the same length as the following piliform spinules, terminating in 3 large spines; this type of armament is intermediate between Type A and Type B, and I incorrectly stated it was Type $A_3$ (Roth 1985b)]. The tarsal claws of the male are minutely but distinctly toothed so I am placing *obtusifrons* in *Margattea.*

Hanitsch (1931b: 392) suspected that *nimbata* was a synonym of *ceylanica,* but he retained the former name because he had not seen the type of *ceylanica.* Later, he (Hanitsch 1933b: 310) claimed to have confirmed this synonymy. Bruijning (1947, 1948) and Princis (1969) listed *nimbata* as a synonym of *ceylanica.* Superficially the two species resemble one another, but the male and female genitalia of *ceylanica* and *nimbata* are distinctly different (cp. Fig. 1 with 18, 23, 26, and Fig. 2 with 19). *Margattea nimbata* is very widely distributed. *Margattea ceylanica* is only known from Sri Lanka, and all records of this species outside of that island probably refer to *nimbata.*

One female paralectotype (Type Orth. 89 2/4) in (HDEO) of *nimbata* (supraanal plate and part of genitalia on slide 202) with the same data as the other paralectotypes probably is another species. Unfortunately most of the genitalic structures were lost during slide preparation. However, the hind margin of the supraanal plate lacks the distinctive medial indentation, and the intercalary sclerites and remnant of the paratergites differs from those of *nimbata.*

### ***Margattea perspicillaris* (Karny)**
### NEW COMBINATION
Figs. 27–35

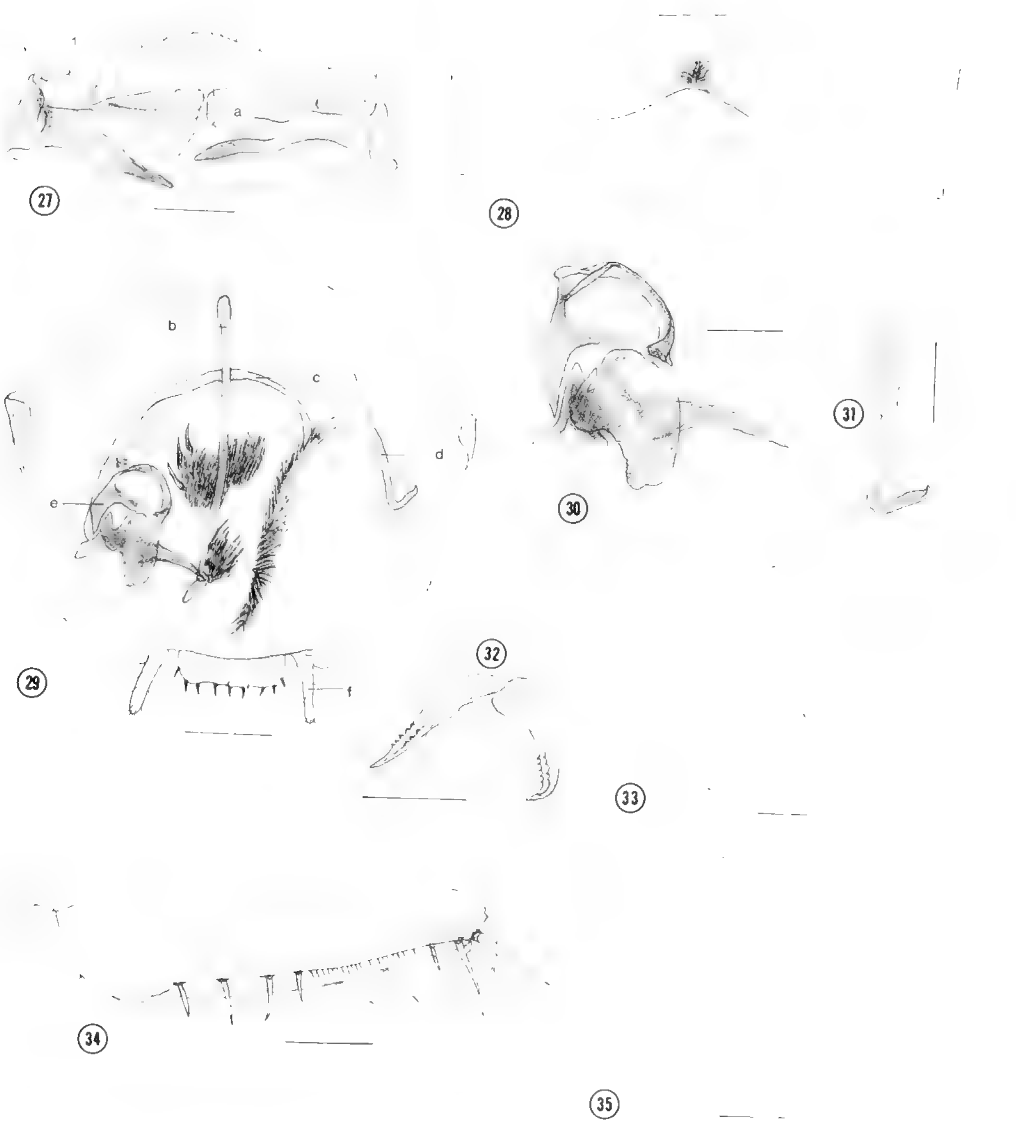
*Theganopteryx perspicillaris* Karny 1915: 103 (♂♀); Hanitsch 1927: 33; Shiraki 1931: 209, Princis; 1969: 1012 (sp. incertae sedis).

*Theganosilpha perspicillaris* (Karny): Kumar and Princis 1978: 33, figs. 27, 28; Asahina 1979: 114, figs. 11–13, 25, 43–50, 60.

Material examined.—Lectotype (labelled by Kumar 1977). Male, Hoozan, Formosa [Taiwan], 1910, H. Sauter; in (DEIG).

Paralectotypes. Taiwan. (DEIG): same data as lectotype, 2 ♂ (1 with terminalia slide 6), 1 ♀.

Male.—Pronotum subparabolic (Figs. 33, 35). Tegmina reaching slightly beyond end of abdomen. Hind wings vestigial, narrow, lateral, reaching between T1 and T2, sometimes longer with venation. Front femur Type $B_3$, tarsal claws minutely serrated, the teeth visible under dissecting microscope (Figs. 32, 34). Eighth abdominal tergum with hind margin concavely indented medially with a posteromedial tuft of setae (Fig. 28), hidden under T7. Supraanal plate transverse, hind margin convex entire, or with a weak indication of a medial indentation;



Figs. 27–35. *Margattea perspicillaris* (Krauss), male types. 27–34, paralectotype: 27, supraanal plate and paraprocts (ventral); 28, abdominal terga 8 and 9; 29, subgenital plate and genitalia (dorsal); 30, left phallomere; 31, hooklike right phallomere; 32, tarsal claws and arolium; 33, pronotum; 34, front femur (anterolateral); 35, lectotype, pronotum. Abbreviations: a, paraproct; b, median phallomere; c, accessory median phallomere; d, hooklike right phallomere; e, left phallomere; f, style. Scales (mm): 27–29, 0.5; 30–31, 0.25; 32, 0.15; 33, 1.0; 34, 0.5; 35, 1.0.

paraprocts similar with a straight spinelike process (Fig. 27). Subgenital plate essentially symmetrical, convex, exposed sides and interstylar regions reflexed dorsad; styles similar, cylindrical, widely separated, between them a rectangular plate, corners rounded, with short robust spines on its hind margin (Fig. 29). Genitalia as in Fig. 29; hooklike right phallomere relatively small, without a preapical spine, apex acute, curved

(Fig. 31); left phallomere with a large spinelike process (Fig. 30); accessory median phallomere with a large setal brush.

Coloration.—Light brown. Head with a weak indication of an interocular band. Pronotal disk with distinct (Fig. 33) or faint (Fig. 34) markings, remaining portion hyaline.

Female.—Tegmina not reaching beyond end of abdomen, extending to about T9; hind wings vestigial. Supraanal plate short, transverse, hind margin broadly convex.

Measurements (mm) (♀ in parentheses). Length, 9.3–9.5 (11.5); pronotum length × width, 2.7–3.1 × 4.0–4.3 (3.0 × 4.5); tegmen length, 7.2–7.9 (7.7).

Comments.—The spined interstylar plate distinguishes the male of *perspicillaris* from the other species described in this paper.

### *Margattea anceps* (Krauss)
Figs. 36–46

*Blatta* (*Phyllodromia*) *anceps* Krauss 1903: 749 (♀).

*Blatta anceps* Krauss: Kirby 1910: 563.

*Phyllodromia anceps* Krauss: Shelford 1908b: 14; Hanitsch 1915: 50; 1923b: 463.

*Margattea anceps* (Krauss): Caudell 1927: 12; Hanitsch 1928: 23 (incorrectly synonymized *nigrovittata* Hanitsch with *anceps*, see remarks below); 1929b: 276; 1932b: 61; 1933b: 310; 1933a: 232; Dammerman 1948: 483, 555; Bruijning 1948: 63; Princis 1969: 864.

*Kuchinga anceps* (Krauss): Hebard, 1929: 42 (♂).

Holotype (not examined). Female, Tjibodas, Java. (According to Krauss, the specimens he described in his paper were preserved "in Spiritus" in the Zoology Department of the "Universitats-Institute zu Jena." Dr. D. v. Knorre of the Friedrich-Schiller-Universitat zu Jena wrote me 28 May 1987 that the type of *anceps* is not in their museum. He also wrote me on 14 October 1987 that the type is not at the Zoological Institute in Tubingen where Krauss worked at that time and that the specimen probably no longer exists.)

Material examined.—Neotype (here designated). Male, Tjibodas, Java, 1500 m, viii.1921, Karny; in (RNHL).

Additional material. Java. (RNHL): same data as neotype, 2 ♂ (one with terminalia slide 141), 1400 m, 1 ♂ (terminalia slide 143), 3 ♀, viii.1921, 2 ♀, vi.1929, Karny; Panggerango, West Java, 1000 m, 1 ♀, 7.vi.1932, M. A. Lieftinck.

Male.—Interocular space less than distance between antennal sockets and ocelli. Pronotum flat, anterior and posterior edges almost straight, lateral edges convex (Fig. 37). Tegmina and wings fully developed. Hind wings with costal veins thickened on distal halves or clubbed apically, discoidal vein straight; median and cubitus veins straight, the former simple, the latter with 3 complete (1 may be forked) and 0 incomplete branches, apical triangle small (Fig. 39). Front femur Type $B_2$ (with 4 large proximal spines); pulvilli present on 4 proximal tarsomeres, tarsal claws symmetrical, ventral margins minutely toothed, arolia present. Eighth abdominal tergum with hind margin concavely indented and arched, bearing a tuft of setae (Fig. 43). Supraanal plate transverse, hind margin narrowly truncate medially, reaching to hind margin of subgenital plate; right and left paraprocts similar, without spinelike processes (Fig. 42). Subgenital plate subsymmetrical, exposed margin rounded, styles cylindrical, similar, separated by about their lengths, interstylar margin straight, accessory stylelike processes absent (Fig. 44). Genitalia as in Figs. 44–46; apex of hooklike right phallomere concavely excavated; median phallomere with a preapical branch, distal region broadened and terminating in a spine.

Coloration.—Head yellowish brown with a broad transverse dark brown band on vertex, occiput pale, sometimes with pale spots between antennal sockets and on face (Fig. 36). Pronotal disk with reddish brown symmetrical pattern (Fig. 37). Tegmina with

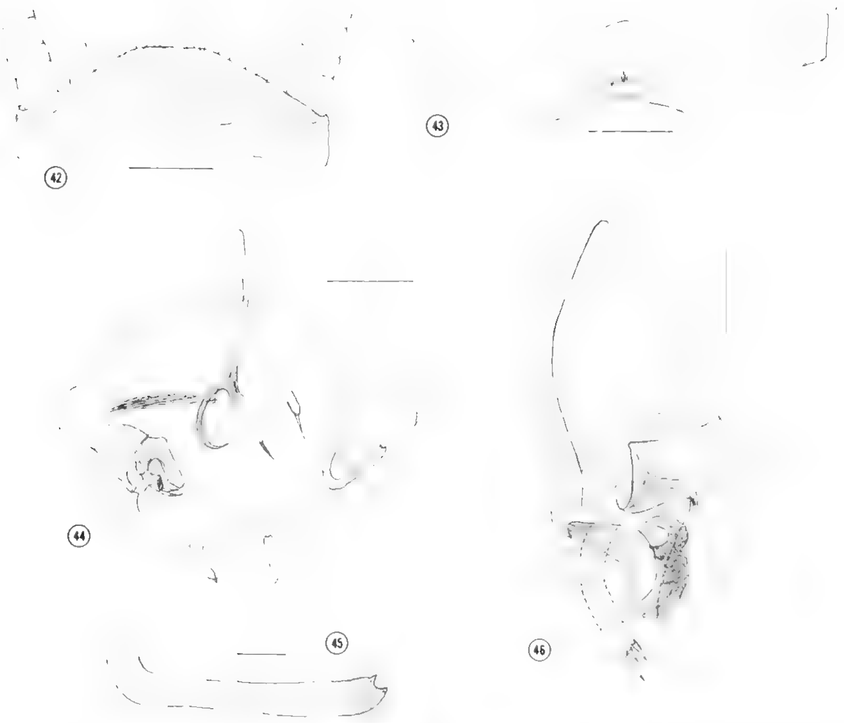
Figs. 36–41. *Margattea anceps* (Krauss), female from Panggerango, West Java: 36, head; 37, pronotum; 38, terminal abdominal segments (dorsal); 39, hind wing; 40, maxillary palp; 41, tegmen. Scales (mm): 36–38, 1.0; 39, 4.0; 40, 0.5; 41, 4.0.

dark brown on basal portion; that part of the right tegmen covered by the left may be darkened whereas the similar area on the left tegmen is pale; the extent of dark areas on the tegmina varies from a small region, e.g. Fig. 41, to large areas extending the length of the wing cover. Abdominal terga light to dark brown, if the former with dark infuscation along posterior borders of the segments; tergal gland area on T8 and posterior part of T7 pale, supraanal plate with a small pale dot on posteromedial region near the hind margin. Abdominal sterna light or dark brown; pale specimens may have a small dot and some infuscation laterally. Cerci pale dorsally. Legs pale.

Female.—Interocular space about the same as interocellar distance, less than the space between antennal sockets (Fig. 36). Supraanal plate transverse, hind margin weakly convex, not reaching hind margin of subgenital plate which is large and laterally overlaps several of the abdominal terga (Fig. 38). Pronotum as in Fig. 37. Tegmina and wings (Figs. 39, 41), and maxillary palps (Fig. 40) as in male. Abdominal terga and sterna very dark brown, subgenital plate with a large mediobasal yellowish spot.

Measurements (mm) (♀ in parentheses). Length, 8.5–10.0 (9.0–10.1); pronotum length × width, 2.2 × 3.0–3.1 (2.2–2.4 × 3.1–3.2); tegmen length, 11.0–12.0 (11.0–11.8).

Comments.—Although the holotype of *M. anceps* apparently is lost, the present material is from the same locality (Tjibodas) and the females agree closely with Krauss's description of that sex. Hanitsch synonymized *M. nigrovittata* (Hanitsch) with *anceps,* probably because of the tegminal markings and interocular band in both taxa. Nevertheless, tegmina with brownish markings and interocular bands occur in species other than *anceps.* I have seen the types of



Figs. 42–46. *Margattea anceps* (Krauss), male from Tjibodas, Java: 42, supraanal plate and paraprocts (ventral); 43, abdominal tergum 8; 44, subgenital plate and genitalia (dorsal); 45, distal part of right genital phallomere; 46, left genital phallomere. Scales (mm): 42–44, 0.5; 45, 0.1; 46, 0.15.

*nigrovittata* and the male's styles and genitalia differ markedly from those of *anceps*. Both are valid species.

### *Margattea contingens* (Walker)
Figs. 47–61

*Blatta contingens* Walker 1868: 229 (♀).

*Phyllodromia contingens* (Walker): Kirby 1904: 92; Shelford (1906) 1907a: 490; 1908a: 27; 1908b: 13; Hanitsch 1915: 45; 1923a: 198; 1923b: 402; Dammerman 1929: 112; 1948: 483.

*Blattella contingens* (Walker): Dammerman 1922: 107; Karny 1925: 188, fig. 20.

*Kuchinga contingens* (Walker): Hebard 1929: 45.

*Margattea contingens* (Walker): Hanitsch 1929a: 13; 1936: 392; Bruijning, 1948: 63.

*Blatta humeralis* Walker 1869: 140 (♂); Hanitsch 1915: 45.

*Phyllodromia humeralis* (Walker): Kirby 1904: 91; Shelford (1906) 1907a: 490, pl. 30, fig. 4 (synonymized with *contingens*); 1908b: 13; Hanitsch 1923a: 198.

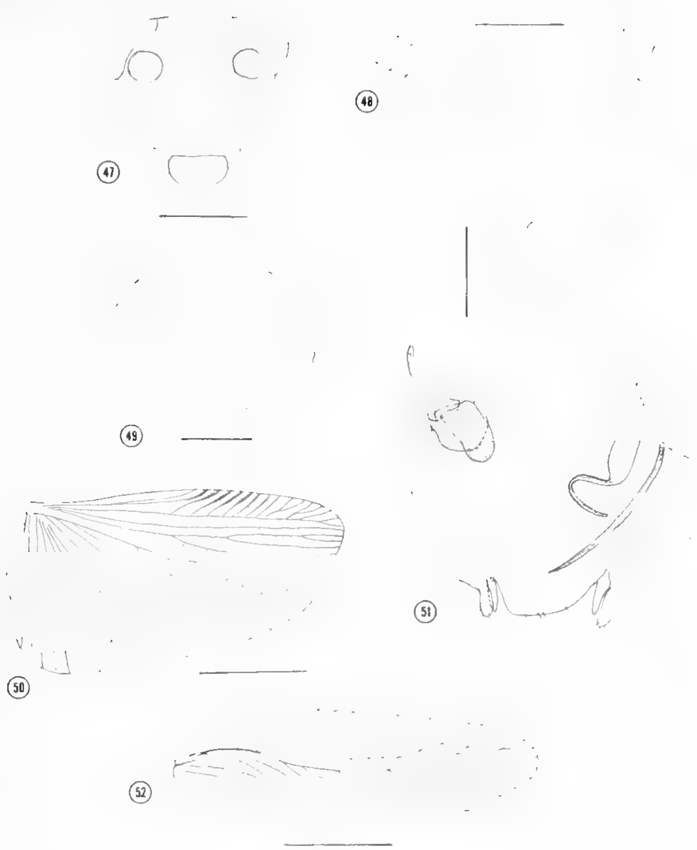
*Kuchinga humeralis* (Walker): Hebard 1929: 45.

*Margattea humeralis* (Walker): Hanitsch 1928: 21 (*contingens* and *humeralis* are distinct taxa); Bruijning 1948: 64; Princis 1950: 174.

*Phyllodromia abrupta* Hanitsch 1923b: 399, figs. 2, 3 (♀).

*Margattea abrupta* (Hanitsch) 1928: 21 (synonymized with *humeralis*); Bruijning 1948: 64.

Material examined.—Holotype. Female (genitalia slide 204) of *Blatta contingens*,



Figs. 47–52. *Margattea contingens* (Walker), male from Long Petak, Borneo: 47, head; 48, supraanal plate and paraprocts (ventral); 49, pronotum; 50, hind wing; 51, subgenital plate and genitalia (dorsal); 52, tegmen. Scales (mm): 47, 1.0; 48, 0.5; 49, 1.0; 50, 3.0; 51, 0.5; 52, 3.0.

Sarawak, Wallace, coll. (1830–73), W. W. Saunders, purchased and pres. '73 by Mrs. F. W. Hope; Type Orth. 77 (HDEO).

Singapore. (HDEO): Male (terminalia slide 199) holotype of *Blatta humeralis*, Wallace, E. coll. (1830–73), W. W. Saunders, purchased and pres. '73 by Mrs. F. W. Hope, Type Orth. 78.

Borneo. (RNHL): Long Petak, 450 m, 1 ♂ (terminalia slide 145), 2 ♀ (1 with genitalia slide 146), ix.1925, H. C. Siebers, M. O. Borneo Exp.

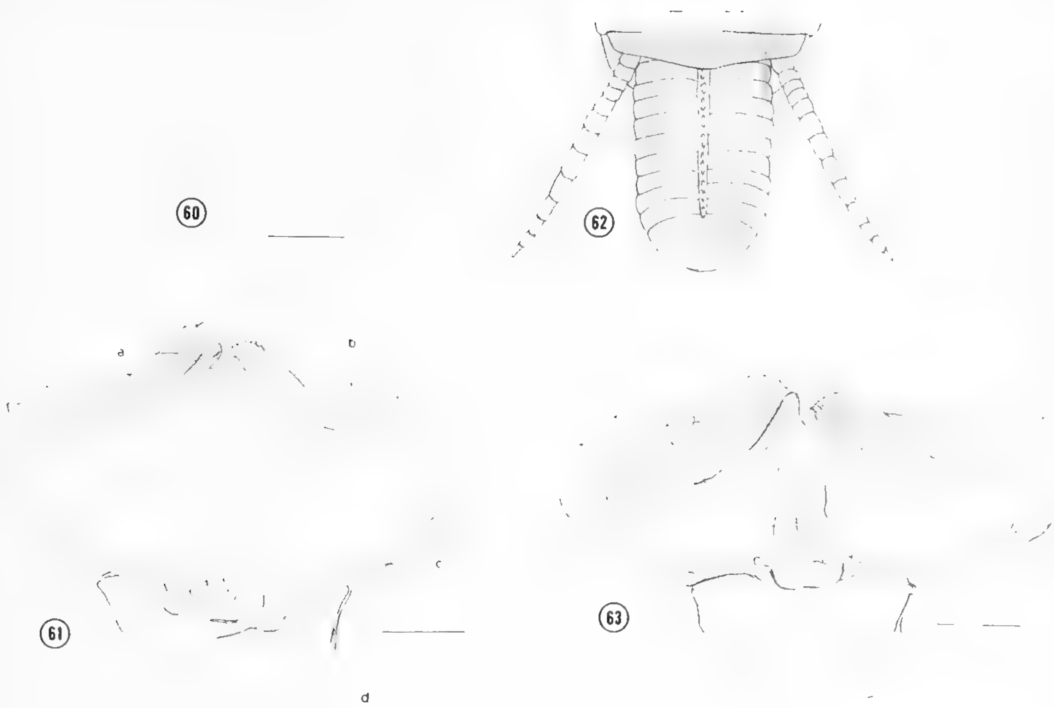
Male.—Interocular space about the same as distance between the antennal sockets (Fig. 47). Maxillary palps with third segment slightly longer than the fourth, each distinctly longer than the fifth. Pronotum suboval (Figs. 49, 53). Tegmina and wings fully developed extending well beyond end of abdomen. Hind wing with costal veins weakly thickened distad, median vein simple, cubitus vein straight with 3 complete and 0 incomplete branches, apical triangle small (Fig. 50). Front femur Type $B_2$ (with 5 proximal spines). Eighth abdominal tergum unspecialized. Supraanal plate transverse, rectangular, hind margin truncate not reaching hind margin of subgenital plate; right and left paraprocts similar (Figs. 48, 54). Subgenital plate weakly asymmetrical, lateral corners produced, stylelike (not articulated), styles similar, cylindrical, each arising basally on the inner margin of the lateral projections (appear to be 4 styles),

Figs. 53–59. *Margattea contingens* (Walker), male holotype of *Blatta humeralis* Walker: 53, pronotum; 54, supraanal plate and paraprocts (ventral); 55, distal region of subgenital plate showing hind margin and styles (dorsal); 56, right posterior corner of subgenital plate; 57–59, left, right, and median genital phallomeres. Abbreviation: a, style. Scales (mm): 53, 1.0; 54, 55, 0.5; 56–58, 0.15; 59, 0.25.

interstylar margin slightly asymmetrical, not or only slightly produced beyond the tips of the styles (Figs. 51, 55, 56). Genitalia as in Figs. 51, 57–59; hook on right side, strongly curved, apex rounded without an apical spine or incision; the median phallomere is a slender, tapering, apically acute rod lying on the right side near the hook (generally the median phallomere lies more or less between the right and left phallomeres; I was careful not to move this structure during slide preparation so its position as shown in Fig. 51 may be normal); left phallomere bulbous on basal half.

Coloration.—Head with an orangish macula on vertex to between the antennal sockets blending into the lighter facial area (Fig. 47). Pronotal disk light brown without distinct markings, surrounding regions hyaline (Figs. 49, 53). Tegmina very pale, yellowish hyaline with a dark streak along the radial vein (this mark may be reduced and only indicated at the base of the vein; Fig. 52). Hind wing infuscated (Fig. 50). Abdominal terga light brown, edges pale. Abdominal sterna lighter, edges darker. Cerci pale dorsally and ventrally.

Female.—Pronotum as in Fig. 60. Su-



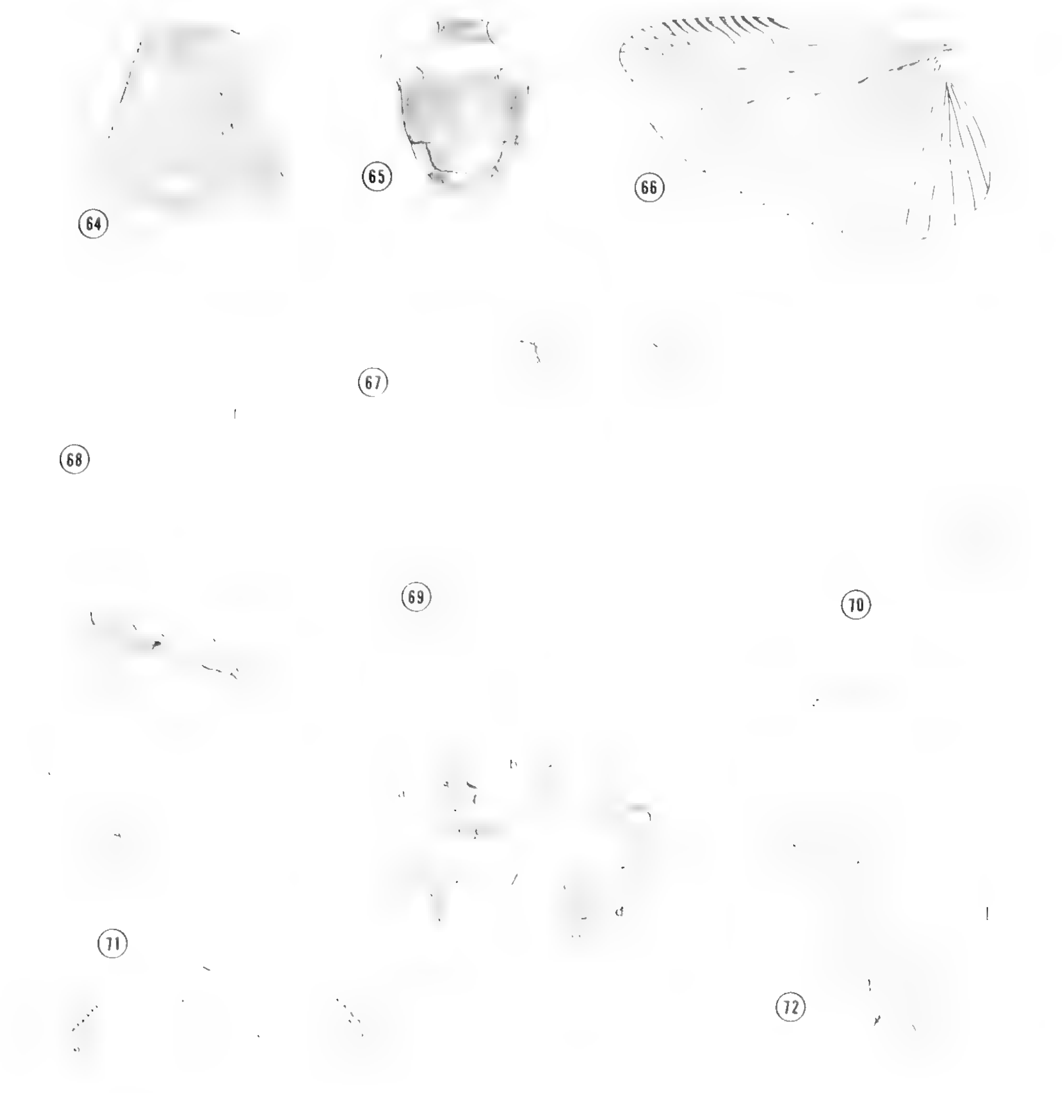
Figs. 60–63. *Margattea* spp. 60, 61, *M. contingens* (Walker), female holotype: 60, pronotum; 61, supraanal plate and genitalia (ventral); 62, 63, *M longealata* (Brunner), females: 62, from 10 miles south of Kuching, Sarawak, ootheca attached to the end of the female abdomen (dorsal); 63, from Sandakan, Sabah, supraanal plate and genitalia (ventral). Abbreviations: a, paraproct; b, supraanal plate; c, paratergite; d, first valvifer. Scales (mm): 60, 1.0; 61, 0.5; 62, 1.0; 63, 0.5.

praanal plate strongly transverse, short, rectangular, hind margin entire (Fig. 61). Genitalia as in Fig. 61; paratergites slender, first valvifer broad, enlarged, connected to the paratergites by slender sclerotizations. Dark streak on radial vein of tegmina greatly reduced. Hind wings lightly infuscated.

Measurements (mm) (♀ in parentheses). Length, 7.4–9.6 (7.7–9.5); pronotum length × width, 2.2–2.4 × 3.1–3.2 (2.3–2.7 × 3.0–3.5); tegmen length, 10.4–10.5 (11.0–12.0).

Comments.—Shelford (1907a: 490) synonymized *humeralis* (♂) with *contingens* (♀). Hanitsch initially agreed with him but later (Hanitsch 1928: 27) considered both species distinct, basing his conclusion on the presence of a brown streak along the radial vein of the tegmen of *humeralis,* and absent in *contingens.* Hebard (1929: 45) agreed with Hanitsch. I do not believe that this color difference is sufficient to separate these two taxa. In the male *contingens* from Long Petak Borneo, the streak on the tegmen is subobsolete, but the important characters (absence of a tergal gland, genital phallomeres, subgenital plate, and styles) are so similar to the holotype of *humeralis* that I am certain they are the same taxon. Also the females from Long Petak are very similar to the ♀ holotype of *contingens* from Singapore.

Although *M. longealata* is strikingly different in coloration from *contingens* the male characters, so similar in both taxa, leave no doubt they are very closely related. The female genitalia of *contingens* (Fig. 61) also



Figs. 64–72. *Margattea longealata* (Brunner). 64, 65, female from 10 miles south of Kuching, Sarawak, pronotum and head. 66–72, male from Sandakan, Sabah: 66, hind wing; 67, supraanal plate and paraprocts; 68, left genital phallomere; 69, subgenital plate and genitalia (dorsal); 70, hooklike right phallomere; 71, tarsal claws and arolium; 72, right corner of hind margin of subgenital plate (dorsal). Scales (mm): 64, 65, 1.0; 66, 2.0; 67, 0.5; 68, 0.15; 69, 0.5; 70–72, 0.15.

are very similar to that of *longealata* (Fig. 63).

### *Margattea longealata* (Brunner)

Figs. 62–72

*Phyllodromia longe-alata* Brunner 1898: 205, pl. 16, fig. 9 (♀).

*Phyllodromia longealata* Brunner: Kirby 1904: 92; Shelford 1908b: 13; Hanitsch 1915: 42; 1923b: 463; 1925: 83 (♂).

*Kuchinga longealata* (Brunner): Hebard 1929: 46.

*Margattea longealata* (Brunner): Hanitsch 1933a: 232; Princis 1969: 865 (the following references erroneously listed by

Princis under *Margattea longealata* actually refer to *Balta longealata* (Hanitsch) Hanitsch, 1930: 254; 1931a: 43; Bruijning 1947: 214—Princis correctly listed these references under *Balta* on page 977 of his catalogue).

Holotype (not examined).—Female, Sarawak; in the Vienna Museum.

Material examined.—Sarawak. (NRSS): Kuching, N. W. Borneo, 2 ♀, 25.v.1900, Dyak coll., pres. 1900 by R. Shelford (det. as *longealata* by Shelford). (ANSP): same data as above, 1 ♂, 1 ♀ (with ootheca), 27.iii.1900, 1 ♂, 30.iii.1900; 10 miles south of Kuching, 1 ♀ (with ootheca), 27.vi.1910, Beebe.

Sabah. (ANSP): Sandakan, Borneo, 1 ♂, 1 ♂ (terminalia slide 401), 1 ♀ (genitalia slide 403), 1 ♀ (carrying ootheca, wall of the ootheca on slide 400), Baker. [All (ANSP) specimens reported as *Kuchinga longealata* by Hebard (1929: 46).]

Borneo. (RNHL): Long Petak, M.O., 450 m, 6 ♂, 10 ♀, ix.1925 or ix.–x.1925, H. C. Siebers, Borneo Exp. (NRSS): Pajau River, O. Borneo, 2 ♂, 2 ♀, Mjoeberg (det. as *Margattea longe-alata* Br., by Hanitsch).

Male.—Interocular space slightly less than space between antennal sockets. Maxillary palps with segments 3 and 4 about equal, each longer than the swollen fifth segment. Pronotum suboval (Fig. 64). Tegmina and wings fully developed extending well beyond the end of the abdomen. Hind wing with costal veins thickened on distal halves, median vein simple, cubitus with 2–3 complete and 0 incomplete branches, apical triangle small (Fig. 66). Front femur Type $B_2$ (with 3 or 4 large proximal spines), tarsal claws with subobsolete teeth on ventral margins (Fig. 71; the denticles cannot be seen under the dissecting microscope but after the claws are treated with KOH and examined under a compound microscope, the weakly defined truncate teeth are seen). Abdominal terga unspecialized. Supraanal plate transverse, narrow, subrectangular, not reaching hind margin of subgenital plate; right and left paraprocts similar, simple plates without spinelike processes (Fig. 67). Subgenital plate symmetrical, its hind margin and styles (Figs. 69, 72) similar to that of *contingens* (cp. Figs. 51, 55, 56). Genitalia as in Figs. 68–70; phallomeres similar to those of *contingens* (cp. Figs. 51, 57–59).

Coloration.—Head brown with a yellowish orange band between antennal sockets (Fig. 65). Pronotal disk with a broad dark brown band whose oblique sides may or may not be margined by narrow yellowish stripes, lateral border regions semi-hyaline (Fig. 64). Tegmina with anterior borders hyaline, remainder dark brown, a continuation of the dark area of the pronotal disk. Hind wings darkly infuscated, thickened region of costal veins whitish or yellowish. Abdominal terga and sterna dark brown. Legs dark brown. Cerci dark ventrally, light on dorsal surface.

Female.—Interocular space less than distance between antennal sockets (Fig. 65). Cubitus vein of hind wing with 2–3 (rarely 4) complete branches. Supraanal plate narrowly subrectangular; paraprocts weakly dissimilar (Fig. 63). Genitalia as in Fig. 63, similar to that of *contingens* (cp. Fig. 61). Ootheca as in Fig. 62; length, 5.5 mm; width, 2.5; height, 1.5.

Measurements (mm) (♀ in parentheses).—Length, 7.2–11.8 (9.3–11.2) pronotum length × width, 2.3–2.7 × 3.0–3.3 (2.7–3.0 × 3.4–3.9); tegmen length, 7.9–11.9 (11.0–13.8).

Comments.—The color markings of *Margattea longealata* are strikingly different from those of *M. contingens.* However, male structures (subgenital plate, styles, genitalia) and female genitalia are so similar in both taxa that one might be tempted to consider *longealata* a color morph, variant, or subspecies of *contingens.* Additional specimens from other localities should be studied to see how variable the color markings are. The unusual ootheca of *longealata* is discussed in the section on subfamily placement. It is likely that *contingens* has a similar ootheca.

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# NOTES ON THE GENUS *ZAGRAMMOSOMA* (HYMENOPTERA: EULOPHIDAE) WITH DESCRIPTION OF A NEW SPECIES

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*Abstract.*—The genus *Zagrammosoma* Ashmead is characterized. The genus *Mirzagrammosoma* Girault is synonymized with *Zagrammosoma,* and the type species, and only included species, *M. lineaticeps* Girault, is transferred to *Zagrammosoma.* New Nearctic distributional records are given for *Z. lineaticeps* from Texas and California, and *Z. mirum* from Washington. New host records are given for *Z. lineaticeps* from *Kieferia lycopersicella* (Gelechiidae) and *Z. mirum* from *Kieferia lycopersicella* and *Phthorimaea operculella* (Gelechiidae) and *Phyllonorycter elmaella* (Gracillaridae). A new species of *Zagrammosoma,* ***Z. hobbesi*** LaSalle, is described from California. A key is given to separate the three species of *Zagrammosoma* which have an entirely black metasoma: *Z. mirum* Girault, *lineaticeps* (Girault), and ***hobbesi*** LaSalle, n. sp.

*Key Words:* Hymenoptera, Eulophidae, *Mirzagrammosoma, Zagrammosoma*

During a study involving *Mirzagrammosoma lineaticeps* Girault, the type species and only included species in the genus *Mirzagrammosoma* Girault, I realized that this genus was a synonym of *Zagrammosoma* Ashmead. At the same time, I came across specimens of a new species of *Zagrammosoma* from Southern California. The purpose of this paper is to formally synonymize *Mirzagrammosoma* with *Zagrammosoma,* characterize *Zagrammosoma,* describe this new species, and provide new host and distributional records for *Z. lineaticeps* and *Z. mirum* Girault.

Morphological terminology follows that of Graham (1969), except that the term mesosoma is used for the thorax (including propodeum), and metasoma used for the combined petiole and gaster (abdomen minus propodeum).

Abbreviations for collections are as follows: AEI, American Entomological Institute, Gainesville, Florida; BMNH, British Museum (Natural History), London; CNC, Canadian National Collection, Ottawa; LAS, personal collection of the author; UCR, University of California, Riverside; USNM, United States National Museum, Washington, D.C.

## Genus *Zagrammosoma* Ashmead

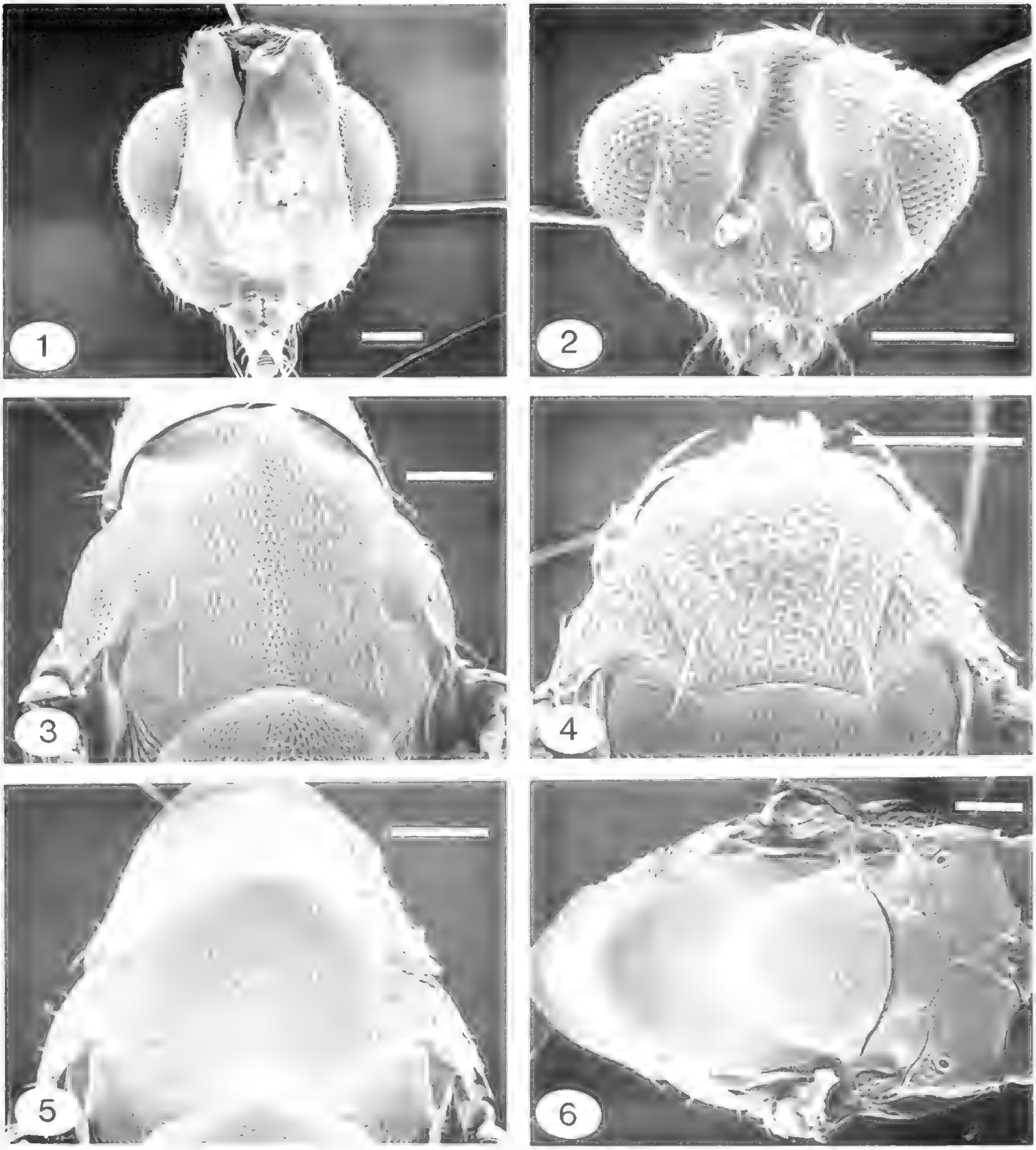
*Hippocephalus* Ashmead, 1888: viii. Type species *Hippocephalus multilineatus* Ashmead (monotypy). Preoccupied by *Hippocephalus* Swainson 1839, in fishes.

*Zagrammosoma* Ashmead 1904: 354, 393. Replacement name for *Hippocephalus* Ashmead.

*Zagrammatosoma* Schulz 1906: 142. Unjustified emendation.

*Atoposoma* Masi 1907: 276. Type species *Atoposoma variegatum* (monotypy).

*Mirzagrammosoma* Girault 1915: 279. Type species *Mirzagrammosoma lineaticeps* Girault (monotypy). **N. syn.**



Figs. 1–6. 1. *Zagrammosoma mirum*, ♀, head. 2. *Cirrospilus flavoviridis*, ♀, head. 3. *Z. mirum*, ♀, mesoscutum. 4. *C. flavoviridis*, ♀, mesoscutum. 5. *Z. hobbesi*, ♀, mesoscutum. 6. *Z. hobbesi*, ♀, dorsum of mesosoma. Scale bars = 0.1 mm.

Diagnosis.—Scutellum with 4 setae (2 pairs); submarginal vein with at least 3 dorsal setae; funicle 2-segmented; notauli complete, curving to meet axilla at a distance well separated from posterior margin of mesoscutum; head with vertex vaulted between compound eyes.

Discussion.—Members of the genus *Zagrammosoma* are parasitic on leafmining Lepidoptera and Diptera. This genus is in the subfamily Eulophinae, tribe Elachertini. The subfamily Eulophinae is characterized by: 4 setae on the scutellum; submarginal vein not broken before it reaches marginal vein, and having 3 or more setae on its dorsal surface; postmarginal vein present and well developed. Elachertini have complete notauli, Eulophini have the notauli incomplete or absent. *Zagrammosoma* is very close to *Cirrospilus,* as both have a 2-segmented funicle, and the postmarginal vein shorter than or equal in length to the stigmal vein. *Zagrammosoma* has been treated as a subgenus of *Cirrospilus* by European authors (Peck et al. 1964, Bouček and Askew 1968), but as a distinct genus by American authors (Peck 1963, Burks 1979). Gordh (1978) also treated *Zagrammosoma* as a distinct genus, and provided a key to Nearctic species. He gave two morphological characters to support *Zagrammosoma* as distinct from *Cirrospilus*: *Zagrammosoma* species have an elongate head which is distinctly vaulted dorsally so that the vertex extends much higher than the compound eyes (Fig. 1); and *Cirrospilus* species have a well developed median carina on the propodeum, while in *Zagrammosoma* this carina is weakly developed or absent. The vaulted vertex is a solid diagnostic characteristic, as it represents a derived character which is unique to *Zagrammosoma* (within the Eulophinae) and this character does not appear in *Cirrospilus* (Fig. 2). However the propodeal carina does not appear to be a good character for the separation of these two genera as it is not constant throughout all the species.

An additional character which may be used to distinguish these two genera is that in *Zagrammosoma* the notaulus curves to meet the axilla, and never reaches, or approaches, the posterior margin of the mesoscutum (Figs. 3, 5); in *Cirrospilus* the notaulus is straight, and extends to the posterior margin of the mesoscutum (Fig. 4).

The genus *Mirzagrammosoma* Girault is herewith synonymized with *Zagrammosoma.* The type species, and only included species, *M. lineaticeps* Girault displays characters consistent with the definition of *Zagrammosoma*: the elongate head with a vaulted vertex; and the notaulus curving to meet the axilla.

There are presently eight species of *Zagrammosoma* known in North America (Gordh 1978); the inclusion of *Z. lineaticeps* and *Z. hobbesi,* n. sp. brings the number up to ten. Gordh treated only one species of *Zagrammosoma* with an entirely black or dark metasoma: *Z. mirum* Girault (Fig. 7). *Z. lineaticeps* also has an entirely black or very dark metasoma, as well as the new species described in this paper, *Z. hobbesi* LaSalle. These three species are the only Nearctic *Zagrammosoma* without any yellow markings on the metasoma, and the following key will serve to separate females of these species.

1. Forewing (Fig. 8) with a longitudinal dark stripe which extends from near the base of the wing to the anterior margin just before the apex, and connects to transverse stripes which extend to the anterior margin of the wing at the junction of marginal and submarginal vein, and at the base of the stigmal vein; apical margin of wing with a transverse stripe in posterior half .... ........................ *Z. lineaticeps* (Girault)

1′. Forewing (Figs. 9, 10) without such a long linear stripe, at most with a U-shaped pattern connecting the junction of the submarginal and marginal veins with the base of the stigmal vein; apical margin of wing without any markings .................................... 2

2. Mesosoma dorsally with broad, median yellow stripe (Fig. 7); venter of mesosoma yellow. Funicular segments both the same color, dark dorsally, brown to yellow ventrally ............................ *Z. mirum* Girault

2′. Mesosoma entirely black, or with only slight yellow markings, not with markings as above. First funicular segment dark, second funicular segment yellow (Fig. 11) .................. ........ *Z. hobbesi* LaSalle, n. sp.

### *Zagrammosoma lineaticeps* (Girault), NEW COMBINATION
Fig. 8

*Mirzagrammosoma lineaticeps* Girault 1915: 279. Holotype ♀, MEXICO, San Rafael, Jicoltepec (USNM) [Examined].

Diagnosis.—*Z. lineaticeps* can be distinguished from the other species of *Zagram-*

*mosoma* with a uniformly black or dark or metasoma by the following characters. Forewing (Fig. 8) with a wide longitudinal dark stripe from the base of the wing which curves to meet the anterior margin of the wing before the apex and which connects to two small transverse stripes which join the anterior margin of the wing at the junction of marginal and submarginal vein, and the junction of marginal and stigmal vein; additionally there is a transverse dark stripe bordering the apex of the wing in the posterior half. Mesosoma entirely black or dark except longitudinal yellow stripe dorsolaterally on pronotum, small longitudinal yellow stripe may be present laterally on mesoscutum; pronotum ventrally yellow. Fore coxa yellow, middle and hind coxae black; fore and middle legs yellow, hind femur and tibia predominantly black, tarsi yellow.

*Z. lineaticeps* is known in the Neotropical region from Mexico, Central America and the Caribbean (De Santis 1979), however it has only been recorded in the Nearctic region from Florida (Burks 1979). Known hosts were in the Agromyzidae and Lyonetiidae. The following represent new distributional records from California and Texas, and a new host record from the tomato pin worm, *Kieferia lycopersicella* (Walsingham) (Gelechiidae).

CALIFORNIA: San Diego Co., Batequitas Lagoon, 1 mi. E. Leucadia, 8.viii.1979, C. W. Melton (8 ♀, UCR).

TEXAS: Cameron Co., Brownsville, 27.vi.1979, E. R. Oatman, ex. *Kieferia lycopersicella* (6 ♀, UCR).

### *Zagrammosoma mirum* Girault

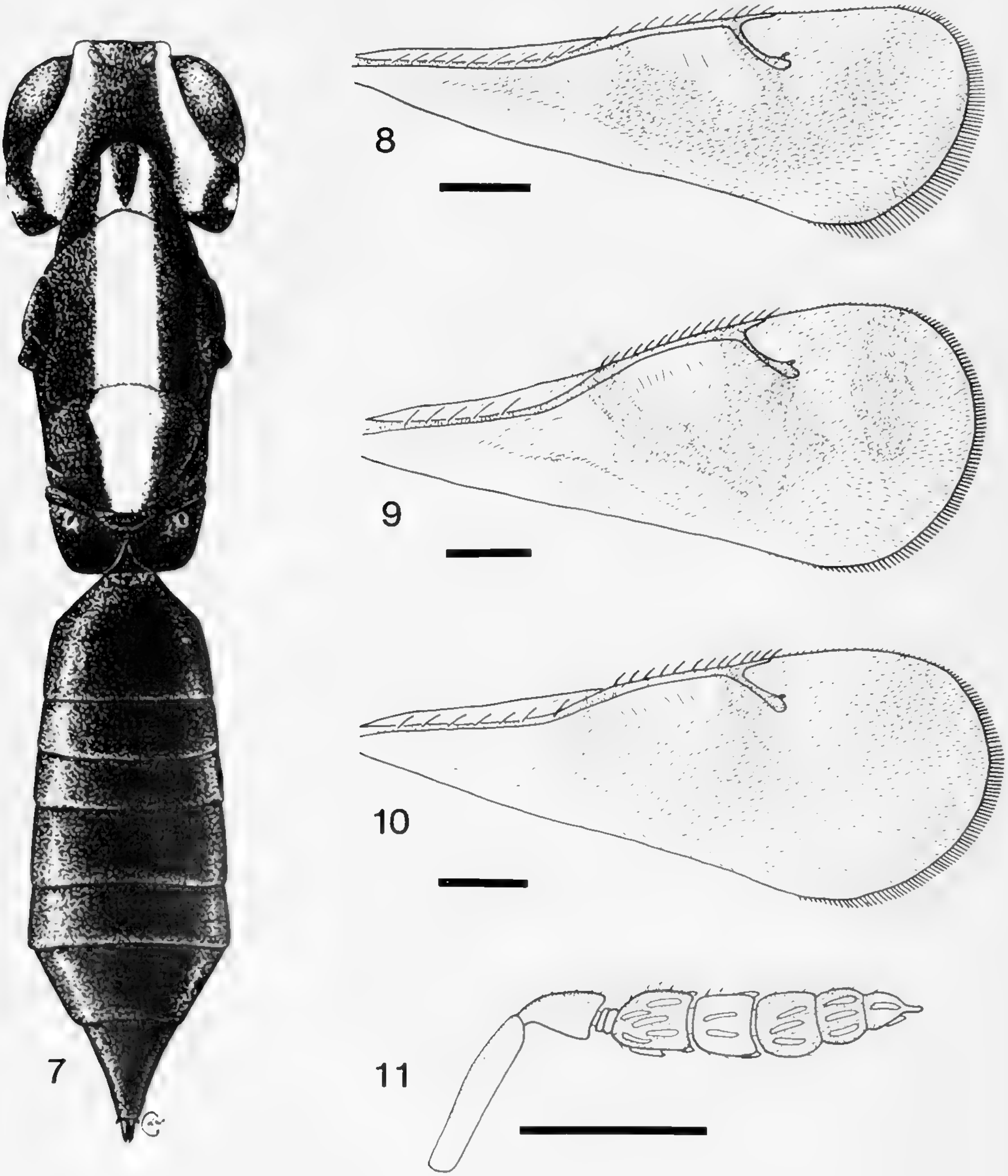
Figs. 1, 3, 7, 9

*Zagrammosoma mira* Girault 1916: 119. Holotype ♀, USA, California, mountains near Claremont (USNM) [Examined].

Diagnosis.—*Z. mirum* can be distinguished from the other species of *Zagrammosoma* with a uniformly black or dark or metasoma by the following characters. Forewing (Fig. 9) without a longitudinal dark stripe or transverse stripe along apical margin; with a transverse stripe at level of base of stigmal vein, these stripes connected posteriorly to form a U-shaped pattern; an additional transverse stripe is present in anterior half of wing between postmarginal vein and wing apex. Dorsum of mesosoma (Fig. 7) black or dark, with a broad longitudinal yellow stripe medially on mesoscutum and scutellum, this stripe becoming two parallel stripes on pronotum; additional thin longitudinal stripe laterally on pronotum. Entire venter of mesosoma yellow. All coxae yellow except hind coxa black basally on dorsum; fore and middle legs yellow, hind femur black except extreme base and apex, remainder of hind leg yellow.

As noted by Gordh (1978), the species of *Z. flavolineatum* Crawford (1913) is very similar to *Z. mirum*, differing only in coloration; *flavolineatum* is slightly lighter colored than *mirum*. In *flavolineatum* the metasoma is uniformly dark brown, but there are small but distinct yellow spots laterally on the metasomal tergites; the propodeum has the callus yellow, as opposed to the propodeum completely black or dark in *mirum*; the hind femur has the entire basal half yellow, as opposed to only the extreme base (only about 0.1× the length of the femur) in *mirum*. *Z. flavolineatum* is known from a single female specimen from Colorado, and this specimen may represent nothing more than a color variant of *mirum*. As Gordh points out, additional material will be necessary to resolve this problem. If they do prove to be synonymous, the name *flavolineatum* would have precedence over *mirum*. Using the key in this paper, specimens of *flavolineatum* would be determined as *Z. mirum*.

*Zagrammosoma mirum* has previously been recorded only from California. Known hosts are in the genera *Lithocolletis* (Gracillaridae) and *Liriomyza* (Agromyzidae).



Figs. 7–11. 7. *Zagrammosoma mirum*, ♀, body (from Gordh, 1978; length 2 mm). 8. *Z. lineaticeps*, ♀, forewing. 9. *Z. mirum*, ♀, forewing. 10. *Z. hobbesi*, ♀, forewing. 11. *Z. hobbesi*, ♀, antenna. Scale bars = 0.2 mm.

Dr. Michael Schauff has kindly informed me that there are specimens of *Z. mirum* in the USNM collection from Wenatchee, Washington, reared from *Phyllonorycter elmaella* (Gracillaridae). Additional new host records for this species are:

CALIFORNIA: Riverside Co., Corona, 31.x.1931, A. J. Baringer, ex. *Kieferia ly-*

*copersicalla* (Gelechiidae) (1 ♀, UCR); Los Angeles Co., Pasadena, viii.1915, J. E. Gray, ex. *Phthorimaea operculella* (Gelechiidae) (1 ♀, UCR).

### ***Zagrammosoma hobbesi*** **LaSalle, New Species**

Figs. 5, 6, 10, 11

Diagnosis.—*Z. hobbesi* can be distinguished from the other species of *Zagrammosoma* with a uniformly black or dark metasoma by the following characters. Forewing (Fig. 10) without a longitudinal dark stripe or transverse stripe along apical margin; with a transverse stripe at level of junction of marginal and submarginal veins, and a transverse stripe at level of base of stigmal vein, these stripes usually not connected posteriorly, but may be faintly connected to form a U-shaped pattern; an additional transverse stripe is present in anterior half of wing between postmarginal vein and wing apex. Entire mesosoma black or dark, except edges of some of the sclerites may be brown or yellow. All coxae black; fore and middle legs yellow; hind femur black except for extreme apex, hind tibia dusky to black basally, yellow apically.

Female.—Length 1.5–2.9 mm. Mesosoma and metasoma entirely black except a small yellow mark laterally on axilla, and anteriorly on tegula. Fore and middle femora and tibiae yellow, hind femur black except yellow apically, hind tibia yellow except usually black basally. Tarsi yellow, distal segments may be brown. Head black and yellow; occiput black with median yellow stripe which extends to vertex and small yellow spot bordering eye; face and frons yellow, with numerous black stripes. Antenna (Fig. 11) with scape yellow, dark dorsoapically; pedicel yellow ventrally, dark dorsally; first funicular segment dark, second funicular segment yellow; basal two club segments dark, third club segment dark basally, yellow apically.

*Head* 1.0–1.2 times higher than wide, the vertex extending distinctly higher than the height of the eyes. Face and frons reticulate. Toruli situated at level of lower eye margin. Eyes 1.2–1.4 times longer than malar sulcus.

*Antenna* (Fig. 11) with scape 4.3–5.2 times longer than wide. Pedicel 1.3–1.5 times longer than wide. First funicular segment 1.25–1.5 times longer than second. Club about equal in length to both funicular segments taken together. Club and funicle about equal in width.

*Mesosoma* (Figs. 5, 6) with pronotum, mesoscutum and scutellum distinctly reticulate, metanotum and propodeum lightly sculptured to smooth. Propodeum with median carina; propodeal callus with 4–7 setae.

*Forewing* (Fig. 10) with a transverse stripe at level of junction of marginal and submarginal veins, and a transverse stripe at level of base of stigmal vein, these stripes usually not connected posteriorly, but may be faintly connected to form a U-shaped pattern; an additional transverse stripe is present in anterior half of wing between postmarginal vein and wing apex. Veins dark except marginal vein yellow. Submarginal vein with 5–8 setae. Submarginal vein 1.45–1.65 times longer than marginal vein; marginal vein 3.0–3.6 times longer than postmarginal vein, 2.15–2.6 times longer than stigmal vein; stigmal vein 1.2–1.7 times longer than postmarginal vein.

*Metasoma* 3.0–4.0 times longer than wide, pointed apically.

Male.—Length 1.1–1.5 mm. Differs from female only in genitalia.

Distribution.—Known only from Southern California.

Material examined.—Holotype ♀. CALIFORNIA, San Bernardino Co., Summit Valley, 14.v.1985, G. Gordh, on *Eriodictyon* (mounted on point, USNM).

18 ♀, 10 ♂ Paratypes. CALIFORNIA: as holotype (7 ♀, 2 ♂, UCR; 3 ♀, USNM); as holotype but on *Haplopappus* (2 ♀, 1 ♂, UCR); San Bernardino Co., Mojave River

Forks, ~9 mi. S. Hesperia, 2.v.1985, J. D. Pinto (3 ♀, 4 ♂, LAS; 1 ♀, 1 ♂: BMNH, CNC, AEI).

Etymology.—The coloration of the face, yellow with numerous black stripes, is reminiscent of the face of a tiger. This species is named for Calvin's tiger friend, Hobbes.

## ACKNOWLEDGMENTS

I thank G. Gordh and J. D. Pinto for supplying material of *Z. hobbesi,* M. E. Schauff for loans of material from the USNM and for host information on USNM specimens, and G. Gordh for supplying the illustration of *Z. mirum.*

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# TWO NEW PHYCITINE MOTHS OF THE GENUS *COENOCHROA* (LEPIDOPTERA: PYRALIDAE) FROM BRAZIL

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*Abstract.*—Two new sibling species of phycitine moths, ***Coenochroa dentata*** n. sp. and ***C. prolixa*** n. sp., are described from Rio Brilhante, Mato Grosso do Sul, Brazil. Reference is made to North American species of the genus. Adult moths and genitalia of both sexes are illustrated and scanning electron micrographs of denuded head capsules and of certain genital structures are included.

*Key Words:* *C. dentata, C. prolixa,* taxonomy, neotropics

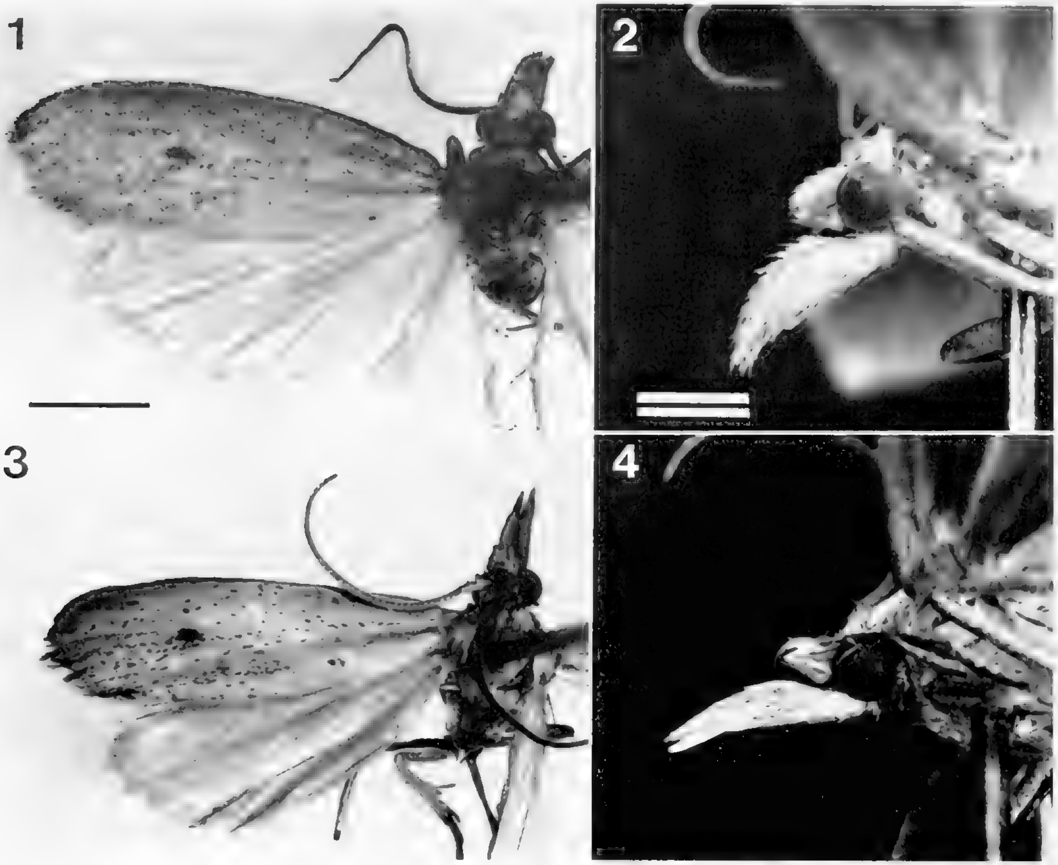
The genus *Coenochroa* Ragonot, 1887 was previously known from three species, all North American. *C. bipunctella* inhabits the Atlantic and Gulf coastal plains, while *illibella* and *californiella* are mainly western, the former extending eastward in the Great Lakes region, the latter ranging south into Panama (Shaffer 1984).

While recently examining a series of pyralid moths collected by Dr. Vitor Becker in Brazil I segregated for further study a small series of specimens from Rio Brilhante, Mato Grosso do Sul which externally resemble *californiella* in size, wing pattern, venation, and frons modification. On dissection these proved to be two undescribed sibling species. The male and female genitalia of these two species fit well within the parameters of *Coenochroa,* are quite distinct in spite of the great external similarity of these moths, and exhibit unusual apomorphies in the male genitalia of both species. These two Brazilian species are described herein with a view to inclusion in the pyralid section of the Checklist of Neotropical Lepidoptera (J. B. Heppner, ed., in prep.).

Although a review of the genus would be premature, I have included a key to the five known species. It is useful to know that: a) only *illibella* has a white costal band, b) all but *illibella* have the dark forewing spot, c) *bipunctella* is the only species in the southeastern U.S.A., d) *californiella* and *illibella* are sympatric and have very similar genitalia for both sexes, but are readily distinguished externally, e) *dentata* and *prolixa* are sympatric and difficult to separate externally, but both sexes have distinctive genitalia. One should refer to Shaffer (1968, 1984) for illustrations and other information pertaining to North American species of *Coenochroa.*

## KEY TO SPECIES OF *COENOCHROA*

1. Male genitalia with valve rounded, unmodified, not dentate; forewing spot present or absent (*illibella*); costal band present (*illibella*) or absent; frons with central beak minute to prominent; North and Central America ...... 2
– Male genitalia with valve dentate; forewing with dark spot at lower outer angle of cell; costal band absent; frons with central beak minute (e.g. Fig. 17) or absent (Fig. 20), varying intraspecifically; Brazil ........................ 4
2. Forewing spot absent; white costal band present; frons with central beak large, protruding well beyond rim of frons modification; western North America and Great Lakes region
*illibella* (Hulst)



Figs. 1–4. Adult moths and head profiles. 1–2, *Coenochroa dentata*, male paratype (USNM slide no. 57864). 3–4, *Coenochroa prolixa*, male paratype (USNM slide no. 57867). Scale bar = 2 mm (Figs. 1, 3), 1 mm (Figs. 2, 4).

– Forewing with dark spot at lower outer angle of cell; costal band absent; frons with the central beak small to absent, not extending beyond rim . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3

3. Central beak of frons extending to rim; aedeagus with vesica bearing numerous small cornuti and single larger one; Atlantic and Gulf coastal plains . . . . . . . . . . . . . . . . . . . . . *bipunctella* (Barnes and McDunnough)

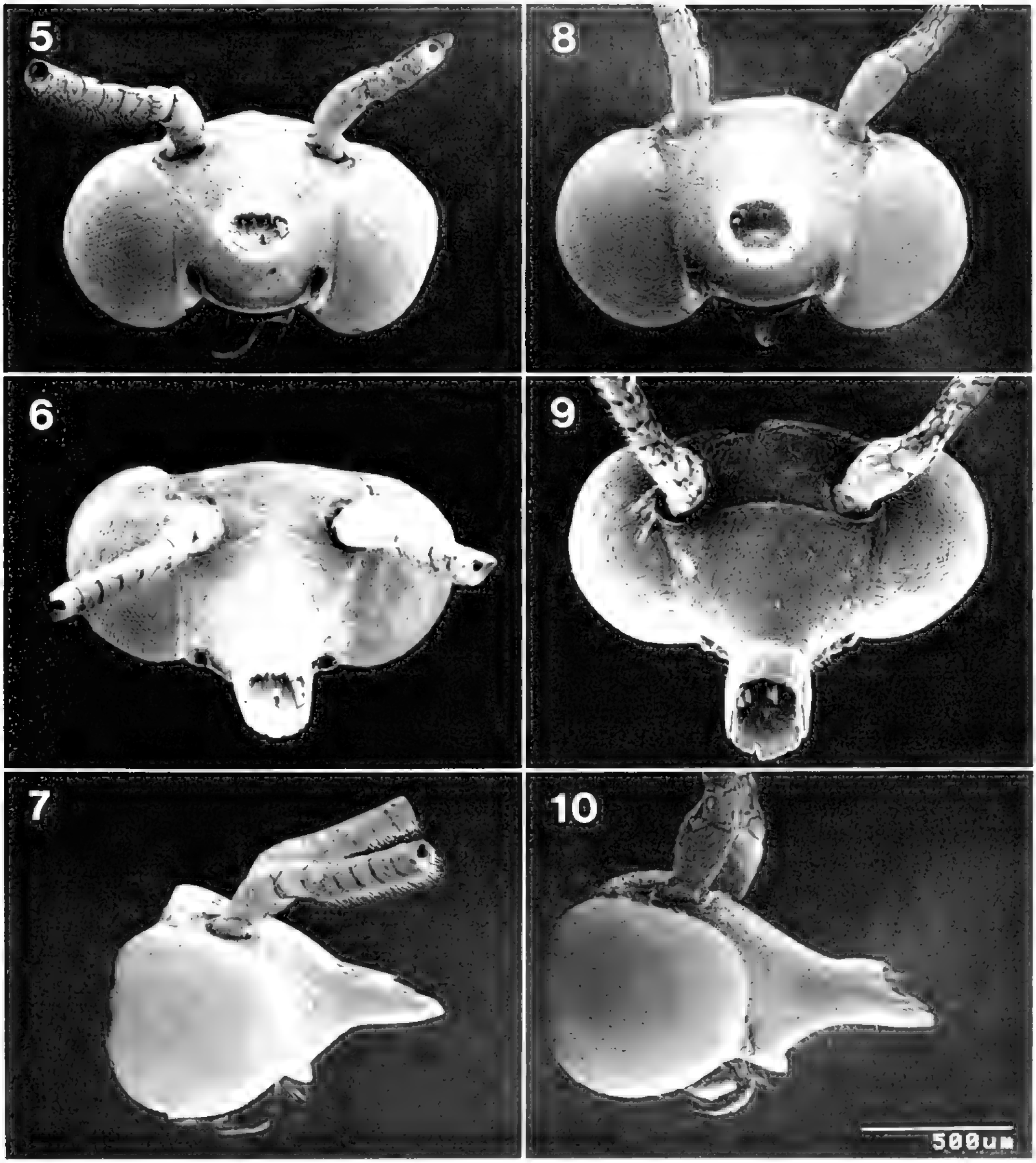
– Central beak of frons minute, not reaching rim; aedeagus with a single long slender cornutus; western North America through Central America . . . . . . . . . . . . . . . . . . . . . . *californiella* Ragonot

4. Forewing light yellowish brown, darker anterior to cell; costa of valve with serrate flange (Fig. 24), vinculum with saccus very short (Fig. 23); ductus bursae straight (Fig. 38) *dentata* Shaffer

– Forewing pale yellow, not darker anterior to cell; costa of valve with single large tooth, saccus very long (Fig. 32); ductus bursae with loop (Fig. 41) . . . . . . . . . . . . . . . . . . . . . . *prolixa* Shaffer

## METHODS

Macerated and cleared genitalia were stained with 0.3% aqueous solution of mercurochrome, mounted in Euparal, and photographed with a Nikon AFM camera on a Nikon S-Ke II microscope set for Koehler illumination. All scanning electron microscope work was done with a Hitachi S-530 SEM at 5 Kv. One head capsule for each of the two species was macerated in hot 10%



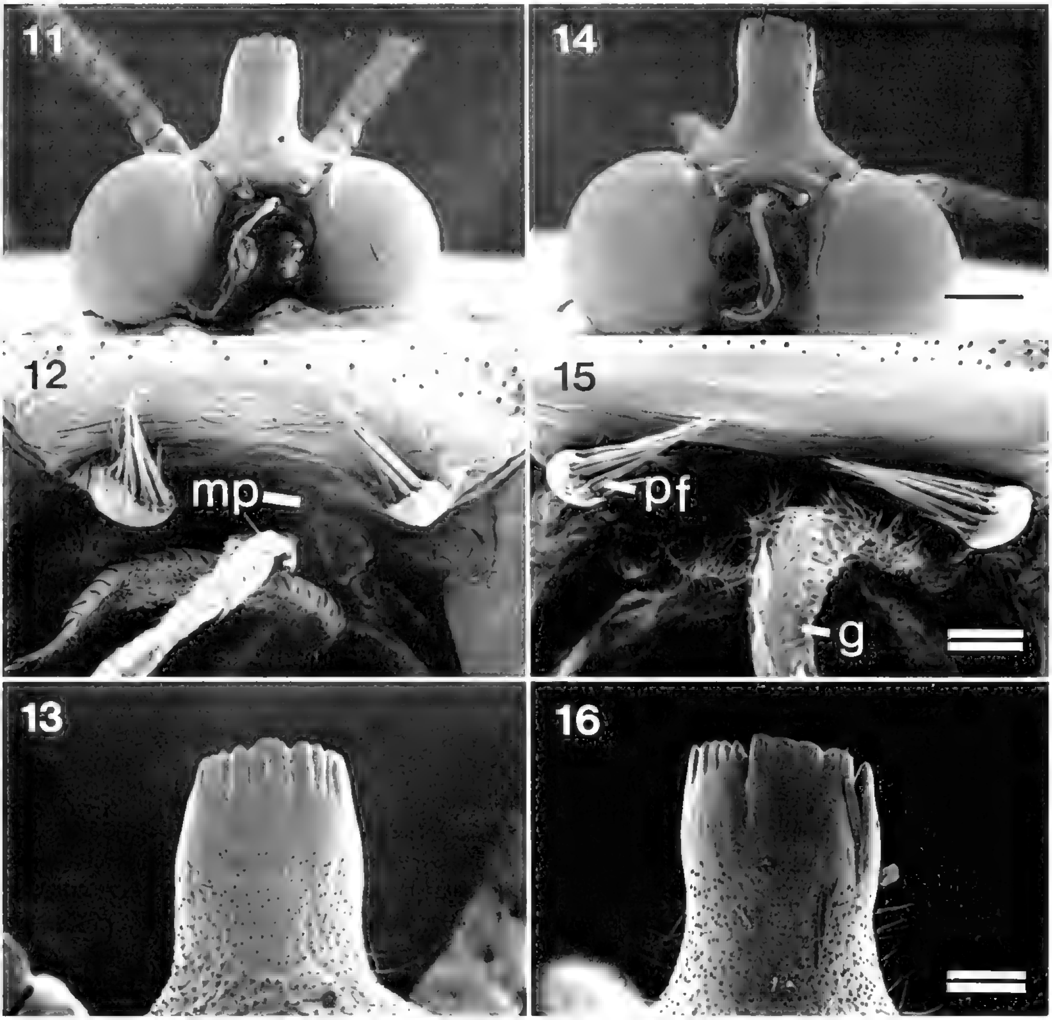
Figs. 5–10. Scanning electron micrographs of denuded head capsules in frontal (top row), anterodorsal (middle row), and lateral (bottom row) views, all to same scale. 5–7, *Coenochroa dentata*, paratype (USNM slide no. 57865). 8–10, *Coenochroa prolixa*, holotype (J. Shaffer slide no. 2239). Scale bar = 0.5 mm.

KOH, cleaned, denuded of scales, mounted from 95% ethanol using silver paint, air dried, and sputter coated with gold. The *dentata* valve (Figs. 30–31) was similarly treated. All original photographs were taken on Kodak Technical Pan Film 2415.

## ***Coenochroa dentata* Shaffer,**
## NEW SPECIES

Figs. 1, 2, 5–7, 11–13, 17–19,
23–31, 38–40

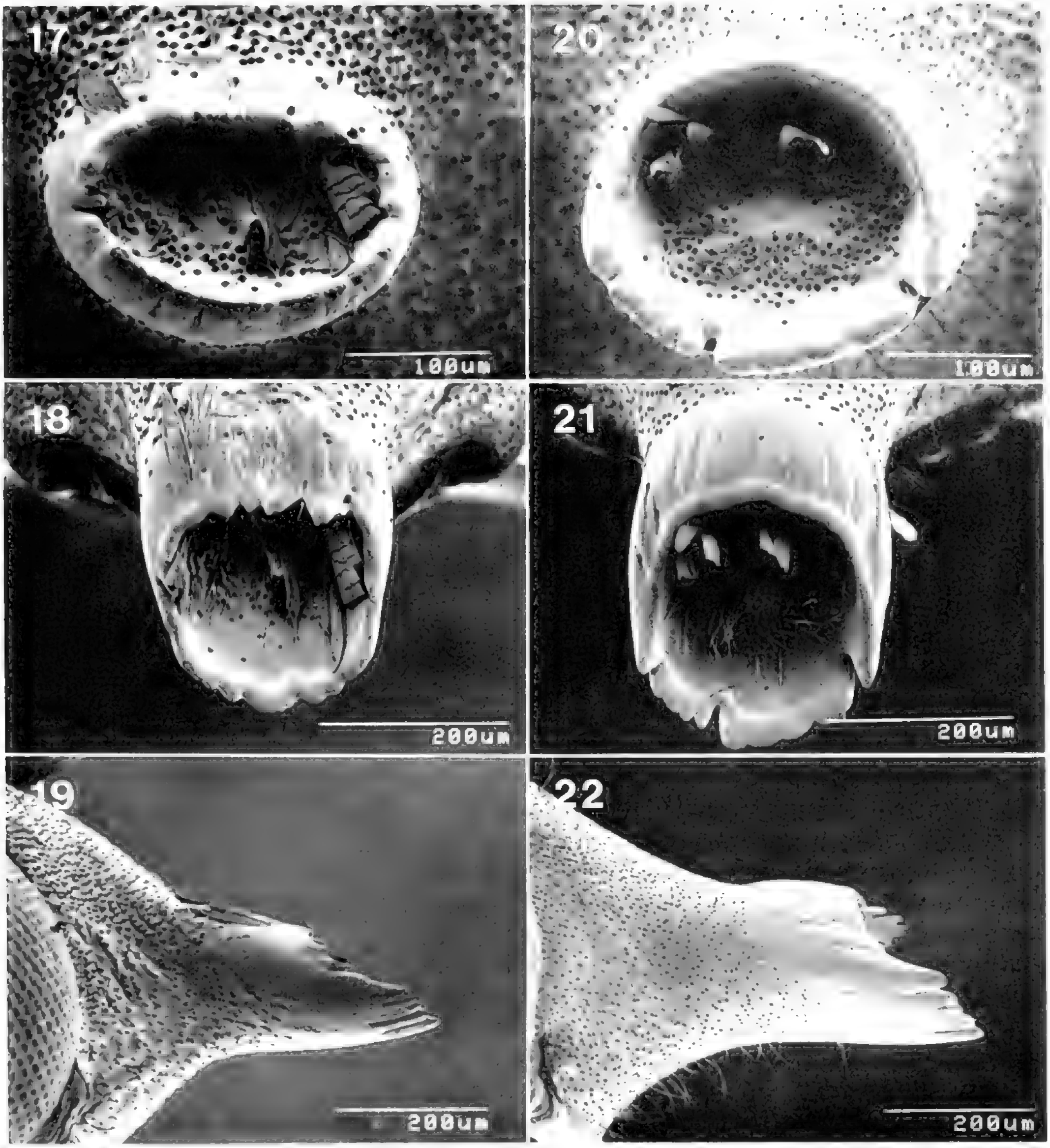
Diagnosis.—Externally very similar to *prolixa*, but with forewing ground light yel-



Figs. 11–16. Denuded head capsules showing ventral aspect (top row), mouthparts (middle row; g = galea, mp = maxillary palpus, pf = pilifer), and ventral view of frons protuberance. 11–13, *Coenochroa dentata,* paratype (USNM slide no. 57865). 14–16, *Coenochroa prolixa,* holotype. Scale bar = 250 μm (Figs. 11, 14), 50 μm (Figs. 12, 15), 100 μm (Figs. 13, 16).

lowish brown, darker and orange brown anterior to cell. Male genitalia with costa of valve bearing serrate flange (Fig. 23); saccus very short; aedeagus with two strong subequal apical spines (Fig. 29). The serrate flange is unique to this species of the genus. Female genitalia with ductus bursae straight (Fig. 38); ostium with lip-like sclerotization.

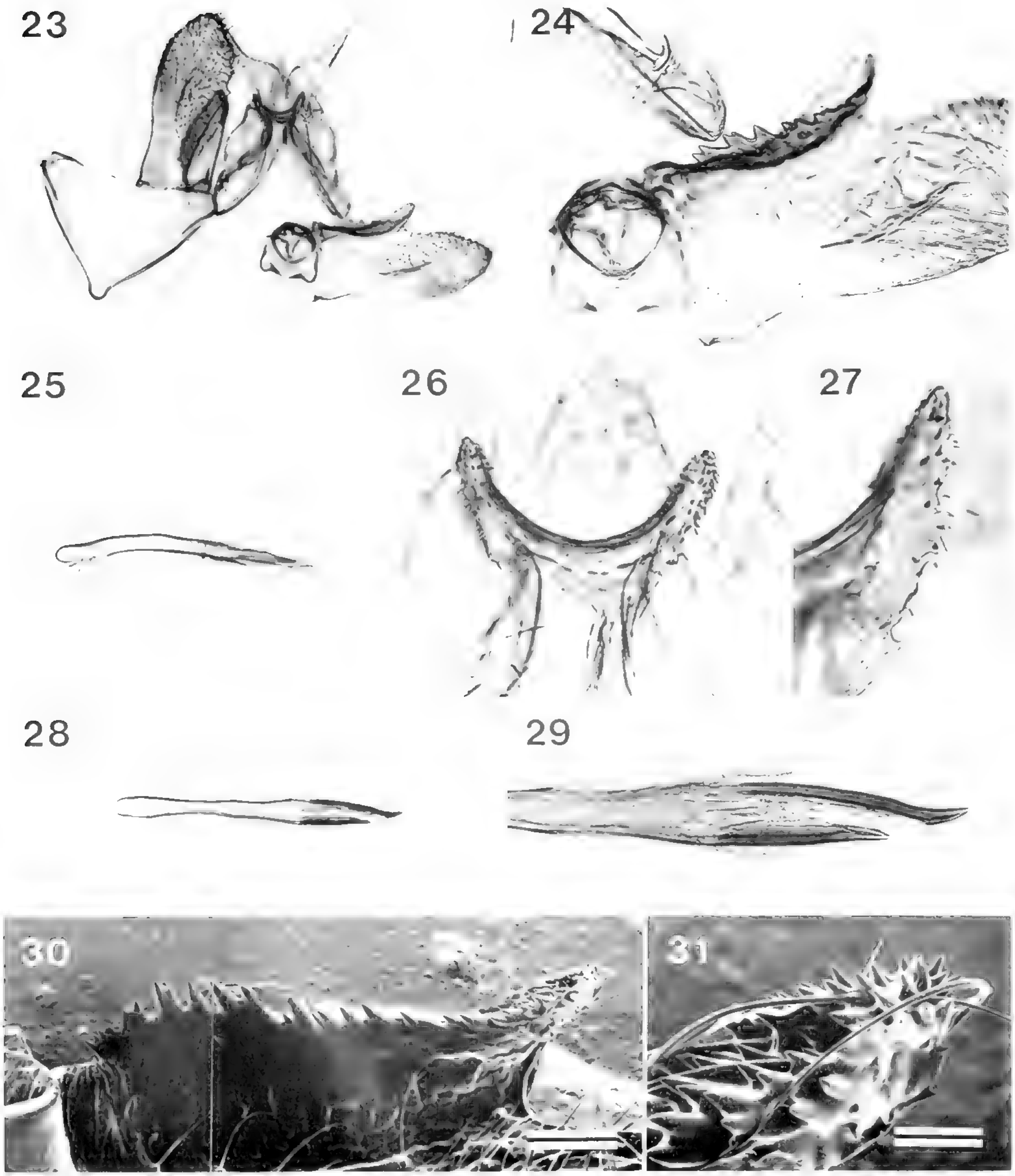
Description.—Frons light brown, darker laterally in some specimens; protuberance completely covered with scales except for extreme tip, form variable (see below). Labial palpus (Fig. 2) deflected, slender, about 3.3 times as long as eye diameter; basal segment about ⅙ as long as second, third about ¼ as long as second; light brown with numerous scattered brown-tipped scales, overall color similar to frons. Maxillary palpus 3-segmented, minute. Proboscis greatly reduced. Ocellus rudimentary. Vertex, oc-



Figs. 17–22. Enlargments of frons protuberances in frontal (top row), anterodorsal (middle row), and lateral (bottom row) views. 17–19, *Coenochroa dentata*, paratype. 20–22, *Coenochroa prolixa*, holotype. Scale bar = 100 $\mu$m (Figs. 17, 20), 200 $\mu$m (Figs. 18, 19, 21, 22).

ciput, patagium, and tegula light brown.

Forewing radius about 8–9 mm; venation variable; $R_1$ usually free, sometimes stalked with $R_{2+5}$; $R_2$ always stalked with $R_{3+5}$, the common stalk variable in length; $R_{3+4}$ stalked with $R_5$, the common stalk variable in length; $M_1$ from upper outer angle of cell; $M_{2+3}$ fused, stalked with $Cu_1$, the common stalk variable in length, from lower outer angle of cell. Ground light yellowish brown,



Figs. 23–31. *Coenochroa dentata,* male genitalia. 23–36, holotype (J. Shaffer slide no. 2254). 27, paratype (USNM slide no. 57865). 28–31, paratype (USNM slide no. 57864). 23, male genitalia. 24, detail showing tubular anellus and serrate costa flange. 25, aedeagus, lateral view, same scale as fig. 23. 26, medial process of gnathos. 27, detail showing gnathos teeth. 28, aedeagus, dorsal view, same scale as fig. 23. 29, aedeagus tip, enlarged. 30, SEM, right valve, ventral view of costa flange. 31, same, detail of costa tip. Scale bar = 100 μm (Fig. 30), 25 μm (Fig. 31).

set with numerous scattered brown-tipped scales, with orange brown cast anterior to cell and posterior to $A_2$, somewhat more yellowish cast on distal half of cell, between $M_1$ and $M_{2+3}$, and in $A_1$ fold. Veins indistinctly marked with white, best developed on cubitus and $A_2$. Distinct brown spot at lower outer angle of cell.

Hindwing light brown, darker at apex. $M_{2+3}$ fused, long stalked with $Cu_1$, from lower outer angle of cell.

Male genitalia (Figs. 23–31) with medial process of gnathos U-shaped, arms minutely spinose, spines irregular, variable (Fig. 27), not extending onto midregion of U-shaped process. Anellus forming sclerotized tube around aedeagus, complete except at dorsal midline. Vinculum broadly triangular, hoodlike, midregion membranous except near saccus; saccus short, about as long as broad. Valve with costa carinate, projecting beyond midregion of valve, dorsal surface a horizontal somewhat concave flange bearing row of strong, irregular teeth on its inner margin (Figs. 24, 30, 31); valve unmodified elsewhere, tip rather broadly rounded. Aedeagus slender, about 10 times as long as maximum width, most slender just anterior to middle, broadest at posterior end; posterior end with a pair of strong parallel spines fused to aedeagus tube, left spine longer and curved at tip, right spine straight, about ¾ as long as left; vesica unarmed.

Female genitalia (Figs. 38–40) with ovipositor triangular, about ⅔ as wide at base as long, moderately setose; typical of genus. Apophyses straight, moderately robust; posterior about 1.25–1.5 times as long as anterior. Eighth segment with scattered moderate setae, except bare anterior third of dorsal surface, ventrally forming pair of triangular lobes which approach each other most closely at posterior of segment, here separated by roughly one-fifth of segment width; ventrally these lobes joined by membrane roughened with numerous minute, closely-set cusps; this membrane extending anterior to ostium and posteriorly to ovipositor lobes as 8–9 intersegmental membrane; 7–8 intersegmental membrane similarly roughened (Fig. 40). Ostium heavily sclerotized, posteriorly lip-like, broadly lobed, lateral margins curving anteriorly. Ductus bursae with anterior half membranous, longitudinally rugose; posterior portion smooth, flat, heavily sclerotized, gradually broadening posteriorly. Corpus bursae round to elongate, membranous, lacking signum; its surface set with minute, rather widely separated scale-like structures rather difficult to discern optically. Ductus seminalis from middle of ductus bursae.

Holotype.—♂, labelled: "Rio Brilhante M Grosso, Brasil 22. I. 1971 Becker leg."; "♂ genitalia on slide 2254 J. C. Shaffer"; "Holotype *Coenochroa dentata* Shaffer" [NMRJ].

Paratypes.—3 ♂, same locality as holotype, dates: 23-I-1971 (USNM slide 57865), [USNM]; 25-I-1971 (USNM slide 57864), [USNM]; 25-I-1971, Becker col. no. 13800, undissected [NMRJ]. 2 ♀, same locality as holotype, dates: 22-I-1971 (J. Shaffer slide 2251), [NMRJ]; 23-I-1971 (USNM slide 57866), [USNM]. All labelled: "Paratype *Coenochroa dentata* Shaffer." Specimen deposition given in brackets.

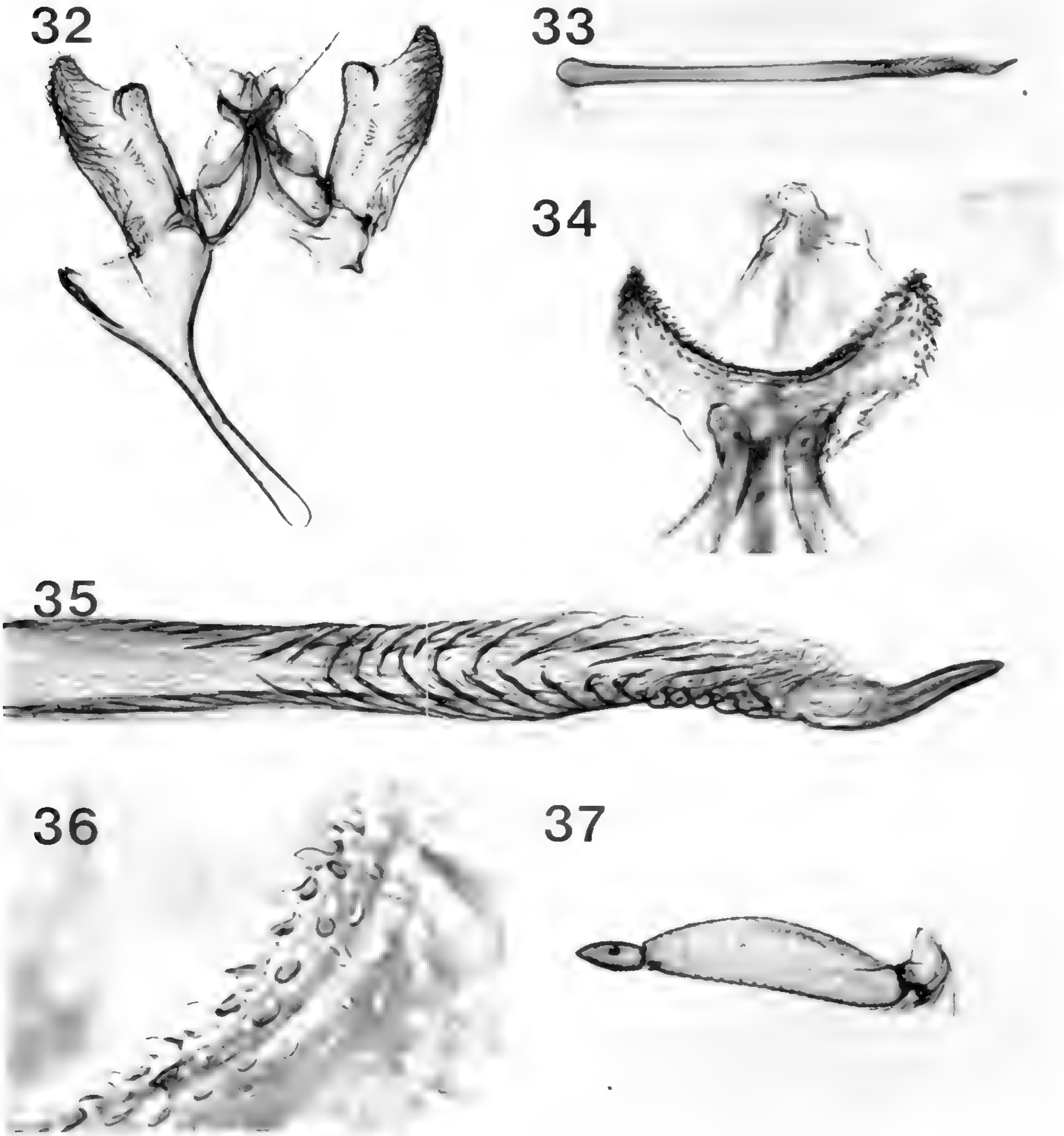
Distribution.—Known only from the type locality.

Etymology.—The specific epithet is an adjective derived from the Latin *dentata* (toothed) in reference to the toothed flange of the valve.

### *Coenochroa prolixa* Shaffer, New Species

Figs. 3, 4, 8–10, 14–16, 20–22, 32–37, 41–43

Diagnosis.—Externally very similar to *dentata,* but with forewing ground pale yellow and not darker anterior to cell. Male genitalia (Fig. 32) with valve costa lacking serrate flange, terminating in blunt tooth; saccus extremely elongated; aedeagus with single apical spine (Fig. 35). Female genitalia with midregion of ductus bursae form-

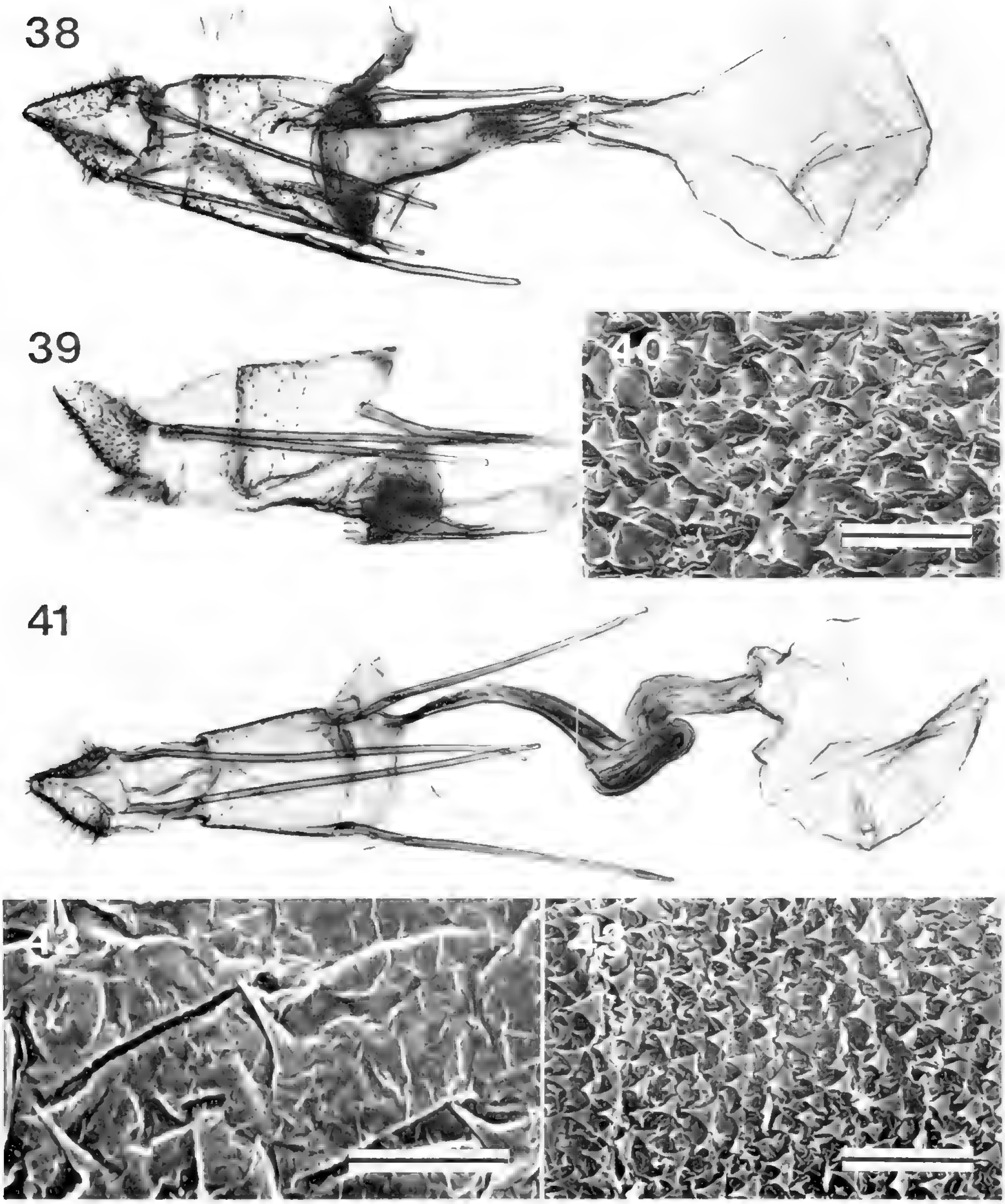


Figs. 32–37. *Coenochroa prolixa.* 32–35, 37, Holotype (J. Shaffer slide no. 2239). 36, Paratype (USNM slide no. 57867). 32, male genitalia. 33, aedeagus, same scale as Fig. 32. 34, medial process of gnathos. 35, aedeagus tip, enlarged. 36, detail showing gnathos teeth. 37, labial palpus.

ing sclerotized loop (Fig. 41). The single large costa tooth, elongate saccus, and ductus bursa loop are each unique to this species of *Coenochroa.*

Description.—Forewing radius about 8–9 mm; venation similar to *C. dentata.* Ground pale yellow throughout, set with numerous darker brown and rust colored scales. Veins marked with white, most notably cubitus and $A_2$. Distinct brown spot at lower outer angle of cell.

Hindwing nearly uniformly grayish white, somewhat darker at apex in some specimens. Venation as in *dentata.*



Figs. 38–43. Female genitalia. 38–40, *Coenochroa dentata.* 41–43, *Coenochroa prolixa,* paratype (USNM slide no. 57868). 38, paratype, dorsal view (USNM slide no. 57866). 39, paratype, lateral view (J. Shaffer slide no. 2251). 40, detail of 7–8 intersegmental membrane (slide 2251). 41, dorsal view. 42, detail of corpus bursae, inner surface. 43, detail of 7–8 intersegmental membrane. Scale bar = 25 μm (Fig. 40), 10 μm (Fig. 42), 25 μm (Fig. 43).

Male genitalia (Figs. 32–36) with medial process of gnathos U-shaped, covered with numerous, minute, rather regular recurved teeth (Fig. 36), these extending onto midline of gnathos, though there much diminished. Juxta platelike, dorsally membranous with sclerotized portion emarginate, ventrally with a pair of short strong protuberances. Vinculum broadly triangular, hoodlike, membranous along midline; saccus extremely elongate, very slender, anterior end somewhat bulbous. Valve with blunt costal projection on distal ⅔; straight single row of about 8–10 setae extending from base of projection toward base of valve, row parallel to and about ⅓ distance across valve from costal margin; valve unmodified elsewhere, tip rounded. Aedeagus very slender, about 20 times as long as wide, distal ⅖ with numerous parallel lateral diagonal folds (Fig. 35), on distal ¼ these folds meeting midventrally to form pattern of chevrons; distal end of aedeagus with a single short stout medially angled spine; vesica unarmed.

Female genitalia (Figs. 41–43) similar to those of *dentata*, differing as follows: broad sclerotized ostium lip absent; sclerotized posterior portion of ductus bursae longer, extremely flattened, curved, not broadened posteriorly; midregion of ductus bursae forming a prominent, heavily sclerotized, thickened loop (Fig. 41).

Holotype.—♂, labelled: "Rio Brilhante, Mato Grosso, Brasil 23–27. X. 1970 V. O. Becker col."; "♂ genitalia on slide 2239 J. C. Shaffer"; "Holotype *Coenochroa prolixa* Shaffer"; [NMRJ].

Paratypes.—♂, same locality as holotype, date: 25-1-197(1), (USNM slide 57867), [USNM]. 6 ♀, same locality as holotype, dates: 25-X-1970 (USNM slide 57863), [USNM]; 27-X-1970, Becker col. no. 13304 (J. Shaffer slide 2256) [NMRJ]; 21-I-1971 (USNM slide 57868), [USNM]; 23-I-1971 (USNM slide 57869), [USNM]; 25-I-1971, Becker col. no. 13925, (J. Shaffer slide 2241), [NMRJ]; 25-I-1971 (J. Shaffer slide 2253), [NMRJ]. All labelled: "Paratype *Coenochroa prolixa* Shaffer." Specimen deposition given in brackets.

Distribution.—Known only from the type locality.

Etymology.—The specific epithet is an adjective derived from the Latin *prolixa* (stretched out) in reference to the elongated saccus.

Apomorphies.—In *dentata* the costal flange and tubular anellus of the male genitalia, and in *prolixa* the elongate slender saccus and loop of the ductus bursae are derived features not shared with any other known *Coenochroa* species.

Immature stages and hosts.—Unknown. The habitus of *Coenochroa* species suggests that the larvae may be associated with grasses.

Discussion.—Dr. Becker (pers. com.) notes that these moths were collected by mercury vapor light in savanna habitat bordering a gallery forest.

These two species are extremely similar externally, and while the forewing color differences noted are useful, I have not found external structural differences that will reliably distinguish all specimens. The frons modification clearly separates the North American *C. californiella* and *illibella,* and obvious differences in the frons structure are seen in the scanning electron micrographs of the two specimens illustrated herein (Figs. 17–22). Unfortunately, optical examination of the remaining specimens suggests that these differences are possibly more a matter of individual than interspecific variability. It will be necessary to examine a larger series of specimens to determine if any frons characters useful in separating these two species exist.

## ACKNOWLEDGMENTS

I am grateful to Dr. Vitor Becker for the opportunity to examine a portion of his collections, to Mr. Jan Endlich for assistance with photoprocessing and SEM work, and to Mr. Vichai Malikul for his comments on preparing the illustrations.

The holotype and selected paratypes are deposited in the National Museum, Rio de Janeiro, Brazil [NMRJ]. The remaining paratypes are in the National Museum of National History, Smithsonian Institution, Washington, D.C., USA [USNM]. The scanning electron microscope used in this study was supported in part by NSF Grant No. BSR-8511148.

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# TYPE MATERIAL OF FOUR AFRICAN SPECIES OF *NOTARCHA* MEYRICK, WITH DESIGNATIONS OF LECTOTYPES AND CHANGES IN SYNONYMY (LEPIDOPTERA: CRAMBIDAE: PYRAUSTINAE)

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*Abstract.*—Lectotypes are designated for three Zeller species: *Notarcha quaternalis, N. temeratalis,* and *N. muscerdalis.* These and the holotype of *N. cassusalis* Walker, the type of *Notarcha,* are redescribed and the wings, head profiles, and female genitalia illustrated.

*Key Words:* *Notarcha quaternalis, N. temeratalis, N. cassusalis, N. muscerdalis,* lectotypes, African Pyraustinae

In his revision of the Pyralidae Hampson (1898: 728) synonymized seven names under *Lygropia quaternalis* (Zeller). In researching our paper (in prep.) on the Crambidae of Aldabra Atoll, we found it necessary to reexamine this synonymy to determine the identity of an Aldabran species erroneously identified in the literature as *quaternalis.* On examining type specimens we discovered that most, perhaps all, of these seven names represent distinct species. The Aldabra species matches none of them and will be described as new.

The purpose of this paper primarily is to designate lectotypes for *quaternalis* and two related African species to provide stability for the names, and secondarily to redescribe and illustrate the three lectotypes and the holotype of an additional species to separate previously confused forms and to facilitate identification.

The African species that Hampson synonymized under *quaternalis* are *temeratalis* Zeller, and *cassusalis* Walker. All three species are properly referred to *Notarcha* Meyrick, 1884, for which *cassusalis* is the type species. In this paper we include the related *N. muscerdalis,* not part of Hampson's synonymy, but of which we studied Zeller's type. *Notarcha* is a large genus with many undescribed species and deserving of extensive study. The scope of this paper is limited to delineating described African species.

Type material referred to herein is in the collections of the British Museum (Natural History) [BMNH], and the Naturhistoriska riksmuseet, Stockholm [NHRM].

## KEY TO INCLUDED SPECIES OF *NOTARCHA*

1. Forewing uniformly yellow, with single dark discal spot (Fig. 4) . . . . . . . . . . . . . . . . *muscerdalis*
– Forewing yellow with transverse lines or diffuse bands of darker yellow; with dark discal spot and 3 similar spots along costal margin 2
2. Labial palpus with third segment mostly dark brown and first segment with brown medial spot (Fig. 5, arrows) . . . . . . . . . . . . . . . . *quaternalis*
– Labial palpus without dark markings . . . . . . . . 3
3. Forewing with anterior half of transverse posterior band in form of diagonal line (Fig. 3) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *temeratalis*
– Forewing with broad diffuse bands, no lines (Fig. 2) . . . . . . . . . . . . . . . . . . . . . . . . . . . *cassusalis*

### *Notarcha quaternalis* (Zeller)

Figs. 1, 5, 9, 13–16

*Botys quaternalis* Zeller, 1852, pp. 44–45.

Diagnosis.—Among the described African species of the *Notarcha quaternalis* complex the dark spot on the basal segment of the labial palpus and the dark third segment (Fig. 5, arrows) are each unique to this species, as is the spiny knob near the entrance to the corpus bursae.

Description (female).—Frons smooth, covered with appressed yellow scales. Labial palpus obliquely ascending; first segment yellow with prominent dark brown medial spot adjacent to eye; second segment yellow; third segment short, subcylindrical, dark brown with yellow apex. Maxillary palpus slender, cylindrical, yellow with subapical dark-brown band. Proboscis scales yellow. Antenna filiform, finely ciliate and with single long cilium near base of each segment; scales light yellow. Eye diameter about 0.75 mm, black. Ocellus prominent, with clear lens surmounted on black elliptical base. Vertex yellow. Occiput and tuft of scales just posterior to ocellus straw colored. Patagium, tegula, and thorax yellow. Forecoxa brownish yellow; forefemur brownish yellow, yellow approaching apex, dark brown at apex; foretibia yellow, dark brown at apex; foretarsus yellow, black markings on basal half and on distal third. [Meso- and metathoracic legs lost on type.]

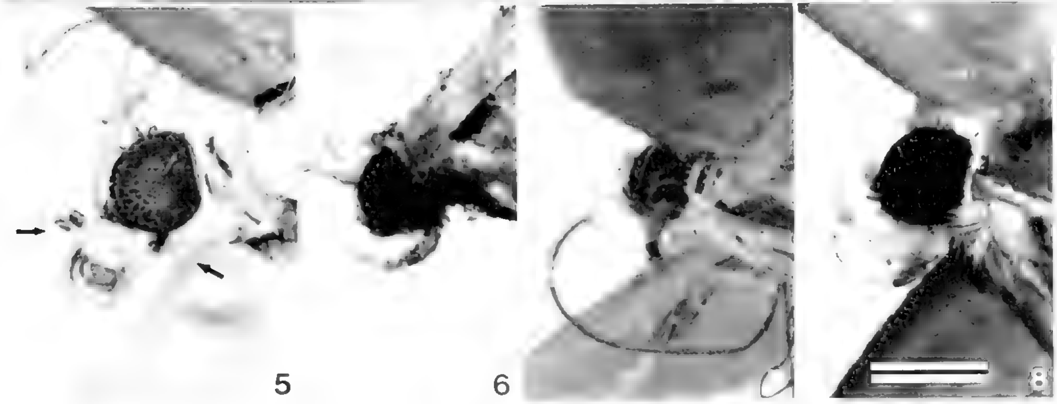
Forewing (Fig. 1) radius 11 mm; with four subequal dark brown spots; first (most basal) spot elliptical, on costa near wing base and separated from it by its own width; second spot elliptical, on costa at one-fifth distance to wing apex; third (discal) spot nearly circular, very slightly larger than first two, on closing vein of cell; fourth spot slightly smaller and more narrowly elliptical than others, very near to costal margin of wing, but separated from margin by about one-third its length. Ground yellow, marked with diffuse transverse lines of darker yellow; three short lines on basal half of forewing, the first descending from the first spot and separated from wing base by its own width; the second from between the first and second spots; the third from just distal to second spot; a fourth line (transverse posterior) descending from fourth spot to just beyond center of wing, angling sharply basad to just beyond posterior outer angle of cell, then angling sharply posteriorly to posterior wing margin; a sixth runs very near to outer margin of wing, broad near wing apex, narrowing posteriorly, and absent from posterior third of wing.

Hindwing with first line indistinct, descending from second of forewing; second line better developed and descending from third of forewing; third line not matched with any forewing line, descending from lower outer angle of cell; fourth line descending from fourth of forewing, somewhat sinuate, its two most distal portions between $M_2$ and $M_3$ and on 1st A; fifth line relatively broad, narrowing posteiorly and approaching posterior end of fourth line; outer margin of wing with distinct dark yellow terminal line; fringe light yellow, darker on basal half.

Lines developed on undersides of both sets of wings; discal spot prominent on underside of forewing, other spots not developed on undersides.

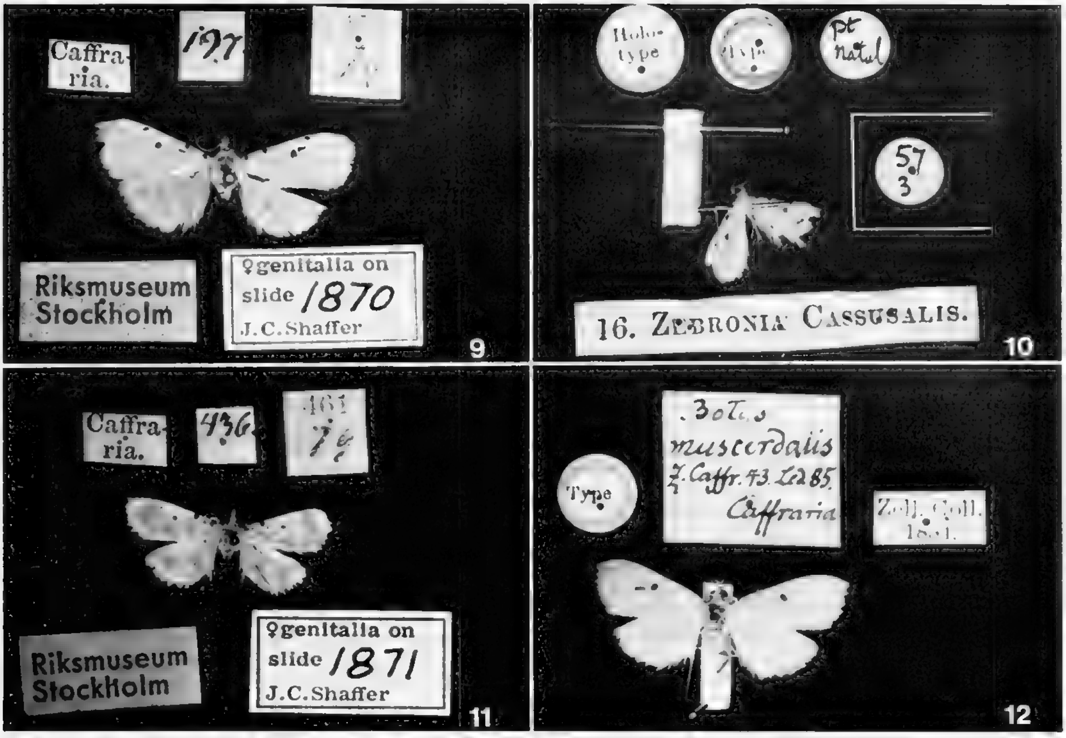
Female genitalia (Figs. 13–16) with ovipositor compressed, with one zone of setae along its inner margin (seen extended in Figs. 13, 14), and a second zone along its outer margin; setae of outer margin densely set and three to four times as long as setae of inner margin. Anterior apophysis nearly twice as long as posterior. Ostial chamber small; immediately adjacent to a flat sclerotized trough; posterior part of inner surface of trough studded with numerous minute, sharp, posteriorly directed spines; anterior part spineless, somewhat granular in appearance. Ductus bursae membranous, with round expanded pouch, studded with numerous minute cusps. Corpus bursae slightly over twice as long as wide; nearly uni-

Figs. 1–4. Wing patterns. 1, *Notarcha quaternalis*, lectotype; 2, *N. cassusalis*, holotype; 3, *N. temeratalis*, lectotype; 4, *N. muscerdalis*, lectotype. Scale bar = 2 mm.



Figs. 5–8. Head profiles of above specimens. 5, *N. quaternalis*; 6, *N. cassusalis*; 7, *N. temeratalis*; 8, *N. muscerdalis*. Scale bar = 1 mm (Figs. 5–8).

formly finely scobinate, each scobination set in center of irregular plate, many plates hexagonal or nearly so; posterior part of bursa with irregular sclerite, spinose on both sides, its posterior end folded into a short knob-shaped pouch with spines facing outward, these spines numerous, slender, sharp pointed; signum absent. Ductus seminalis



Figs. 9–12. Types with labels. 9, *Notarcha quaternalis,* lectotype (1.6×); 10, *N. cassusalis,* holotype, insert shows reverse side of "Pt Natal" label (1.4×); 11, *N. temeratalis,* lectotype (1.6×); 12, *N. muscerdalis,* lectotype (1.4×).

from membranous posterior part of corpus bursae.

Type locality.—Natal, South Africa.

Lectotype, hereby designated, labelled: "Caffraria."; "197"; "Riksmuseum Stockholm"; "♀ genitalia on slide 1870 J. C. Shaffer"; "*Botys quaternalis* Lectotype by J. Shaffer & E. Munroe, 1989" [NHRM].

### ***Notarcha cassusalis* (Walker)**

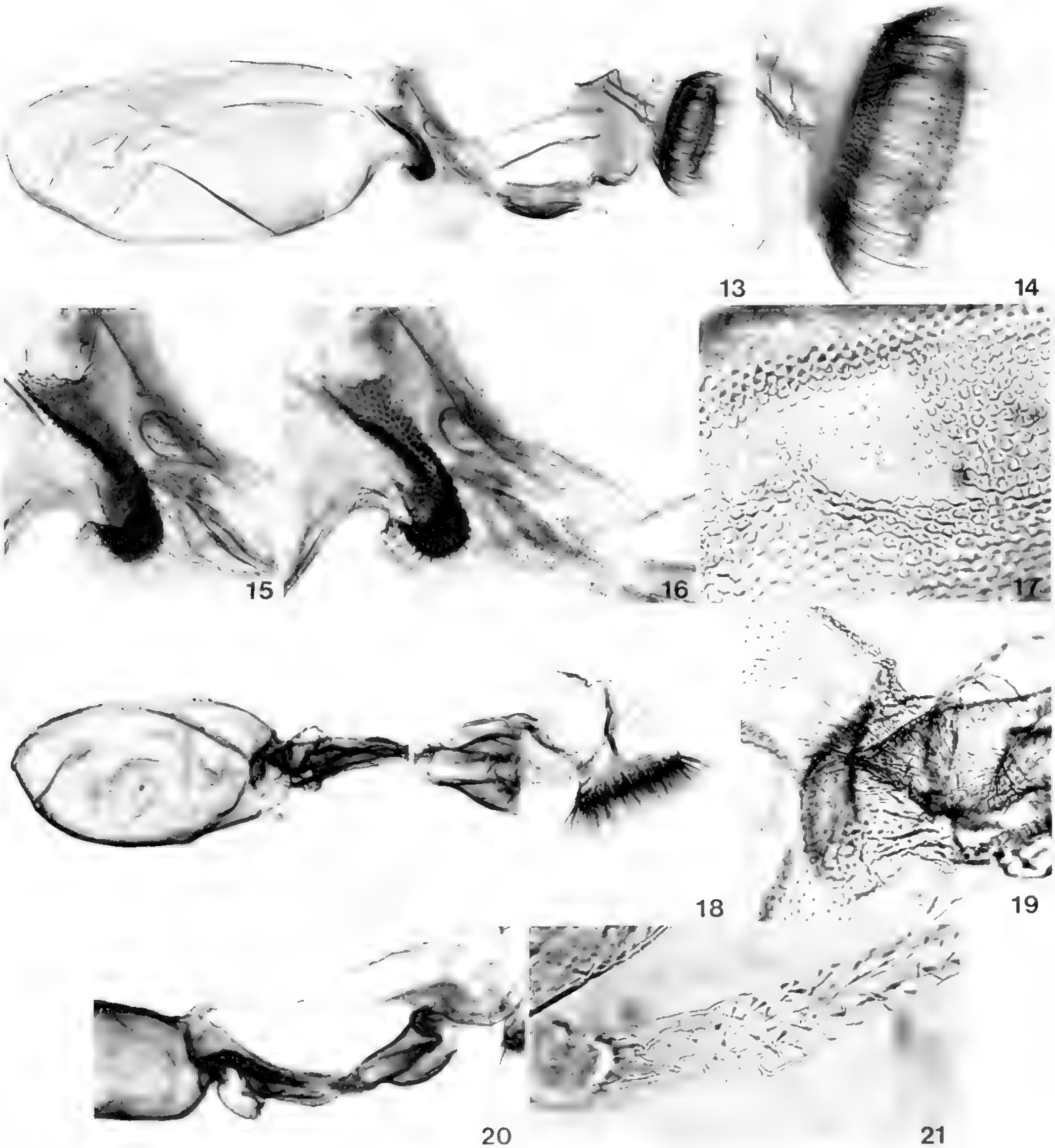
Figs. 2, 6, 10, 17–21

*Zebronia cassusalis* Walker, 1859, p. 477.

Diagnosis.—Among the described African species of the *Notarcha quaternalis* complex this species is externally similar to *quaternalis,* but lacks dark markings on the labial palpus, and has broader more diffuse transverse bands on the wings. The spinose triangular plate at the entrance to the corpus bursae and the internally spinose ductus seminalis are each characteristic of this species.

Description (female).—Frons smooth, covered with appressed yellow scales. Labial palpus obliquely ascending, third segment short, subcylindrical; all segments uniformly yellow on outer side, lacking dark spots of *quaternalis.* Maxillary palpus light yellow. Antenna as in *quaternalis.* Eye diameter about 0.5 mm. Ocellus as in *quaternalis.* Vertex yellow; patagium vivid yellow centrally, lighter peripherally; tegula extending nearly to abdomen, vivid yellow.

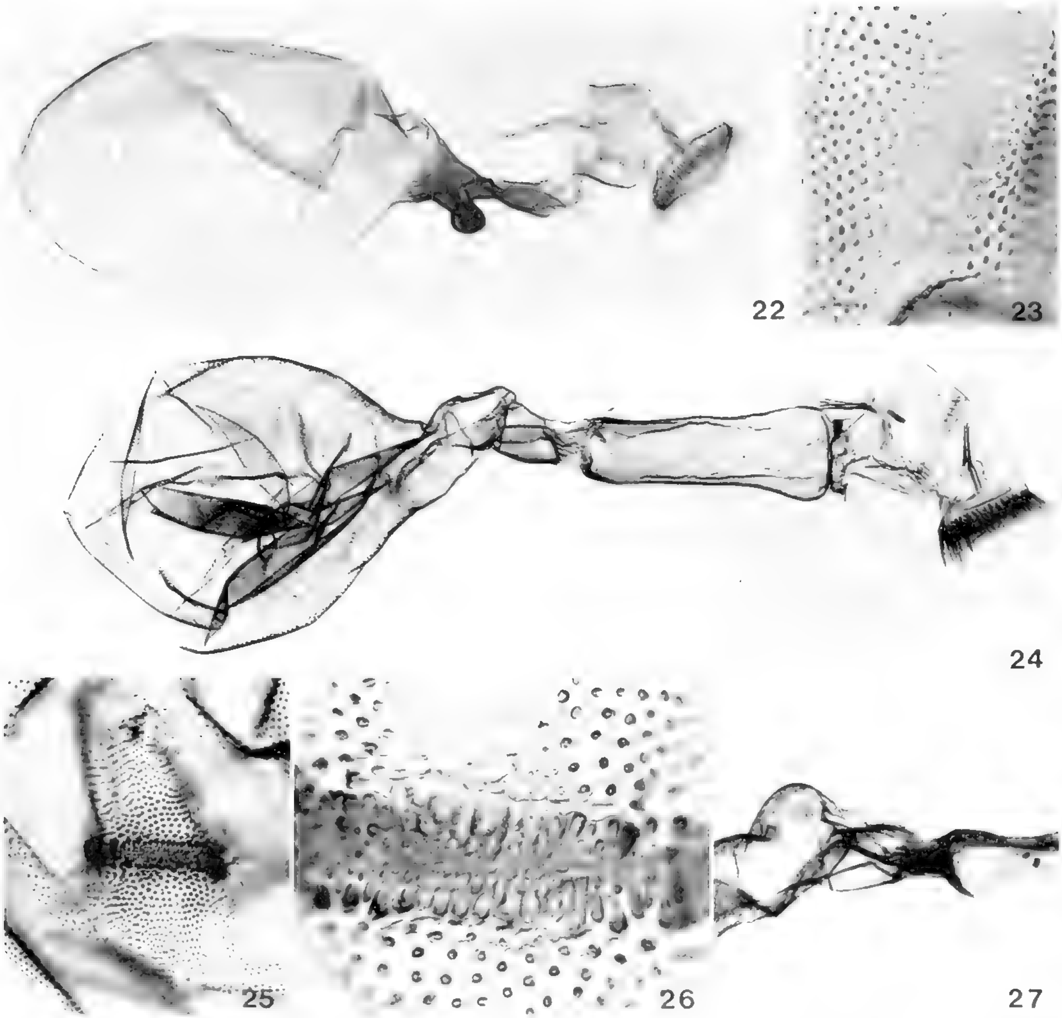
Outer side of forecoxa yellow basally, brown elsewhere; forefemur brown on inner side, light yellow on outer side, small dark brown spot on apex; foretibia yellow on basal half, dark brown on distal half; foretarsus



Figs. 13–21. Female genitalia. 13, *Notarcha quaternalis*, lectotype (20×); 14, ovipositor, enlarged (45×); 15–16, armature at entrance to corpus bursae, two focal levels (50×); 17, *N. cassusalis*, corpus bursae surface, enlarged to show surface texture (220×); 18, female genitalia (28×); 19, armature at entrance to corpus bursae (110×); 20, rotated specimen showing origin of ductus seminalis (28×); 21, ductus seminalis, enlarged to show internal spines (220×).

yellow, brown spot at apex of first segment, smaller spot at apex of second segment, third segment yellow, fourth segment brown, fifth segment yellow. Midfemur rather uniformly light yellow, small dark brown spot at apex; midtibia nearly uniformly light yellow, lacking dark markings; midtarsus light brownish yellow. Metathoracic leg coloration similar to that of mesothoracic leg.

Forewing (Fig. 2) radius about 9 mm.



Figs. 22–27. Female genitalia. 22, *Notarcha temeratalis*, lectotype (28×); 23, corpus bursae surface, enlarged to show surface texture (200×). 24, *Notarcha muscerdalis*, lectotype (23×); 25, signum, enlarged (55×); 26, signum and adjacent bursa surface, enlarged (220×); 27, rotated specimen showing origin of ductus seminalis (28×).

Ground light yellow with broad diffuse vivid yellow bands. Costa with three prominent dark brown spots; spot at basal band reniform, spot on antemedial band the largest of the three, circular, distal spot just beyond midregion of wing and smallest of the three spots. Discal spot dark brown, large and prominent, somewhat triangular with longest side transverse and distal.

Hindwing light yellow with broad diffuse vivid yellow bands.

Female genitalia with ovipositor compressed, moderately setose. Anterior apophysis 1.5 times as long as posterior, slightly decurved; posterior apophysis slender, angled at anterior third and at posterior third. Ostial chamber well sclerotized, broadly expanded posteriorly; anterior one-fifth devoid of spines and somewhat granular in appearance; posterior four-fifths with numerous minute, hairlike spines, these directed inward or posteriorly and shortest along lateral regions of ostial chamber. Ductus bursae membranous on posterior one-fourth; anterior three-fourths with irregular sheetlike sclerotization, this folded longitudinally about one and one-half times, the nearly closed fold with patch of strong inwardly directed spines near its anterior end; other side of sclerotized sheet extending into corpus bursae as strongly setose triangular plate (Fig. 19); anterior part of ductus bursae with small membranous pouch. Corpus bursae nearly twice as long as broad, lacking signum, nearly uniformly finely scobinate (Fig. 17), each scobination set in center of minute plate, plate hexagonal or approximately so. Ductus seminalis from near posterior end of corpus bursae (Fig. 20), membranous, its inner surface set with numerous slender setae (Fig. 21).

Type locality.—Natal, South Africa.

Holotype, labelled: "Holotype"; "Type"; "Pt Natal [& on reverse side] 57 3"; "Zebronia Cassusalis"; "♀ Pyralidae Brit. Mus. Slide No. 18060" [BMNH].

### *Notarcha temeratalis* (Zeller)
### New Combination
Figs. 3, 7, 11, 22–23

*Botys temeratalis* Zeller, 1852, pp. 45–46.

Diagnosis.—Among the described African species of *Notarcha* only *temeratalis* has a portion (anterior half) of the transverse posterior line of the forewing developed as a narrow diagonal line. The species is also unique in that the corpus bursae is unmodified.

Description (female).—Frons smooth, covered with appressed yellow scales. Labial palpus obliquely ascending, third segment short, subcylindrical; all segments white to straw yellow on outer sides, first with indistinct light-brown medial spot adjacent to eye, first and second somewhat darker apically. Maxillary palpus cylindrical, straw yellow. Base of proboscis clothed with straw-yellow scales. Antenna as described for *N. quaternalis.* Eye diameter 0.6 mm, black. Ocellus as described for *N. quaternalis.* Occiput white; patagium yellow anteriorly, white posteriorly; tegula white with yellow medial band. Thoracic vesture of broad white scales beneath head. Forecoxa light brown on inner side, white on outer side; forefemur similar, but with dark-brown apical spot; foretibia yellow basally, distally with tuft of dark-brown scales; foretarsus with dark-brown subapical spot. Midthoracic leg rather uniformly straw yellow, with small dark-brown spot at apex of femur.

Forewing (Fig. 3) radius 9 mm. Ground white, bearing four subequal dark-brown spots; first (most basal) spot nearly round, on costa near wing base and separated from it by its own width, second spot slightly larger, nearly round, somewhat pointed posteriorly, on costa at one-fourth distance to wing apex; third (discal) spot slightly smaller than first two, nearly circular, at outer margin of cell; fourth spot less well developed than other three, in form of oblique dash near costa, not quite reaching wing margin. Ground white with yellow markings in form of line, diffuse bands, and broader diffuse patches; a broad band descending obliquely from second spot to posterior wing margin near base; a second parallel band descending from point midway between second and third (discal) spots to posterior margin, gradually broadening posteriorly; a small yellow patch immediately distal to discal spot; a narrow line descending obliquely distad from fourth spot to 1st A, angled basad between $Cu_1$ and $Cu_2$, then obliquely and basad to posterior margin as broad diffuse band; a broad yellow patch in anterior preterminal area, bordered entirely by white ground; a smaller patch from angle of narrow line to terminus; a well developed thin terminal line of yellow on outer margin of wing.

Hindwing ground white; a diffuse yellow band running basally from cubitus in cell, then angled posteriorly to anal margin; a broad yellow band runs obliquely from posterior outer angle of cell to posterior wing margin; a narrow yellow line descending obliquely from fork of Sc and Rs to Cu1, there broadening to an oval yellow patch just anterior to anal angle, oval patch separated from wing margin by narrow white ground; a large yellow patch near apex bordered entirely by white ground; outer margin with a distinct narrow yellow terminal line, and a similar line on fringe near its base, best developed on posterior half of outer margin.

Undersides of both wings with lines and patches showing, but indistinctly so; discal spot poorly developed, other three spots absent.

Female genitalia (Figs. 22, 23) with ovipositor compressed. Anterior apophysis about 1.7 times as long as posterior. Ostial chamber moderately well sclerotized, somewhat flattened, with margins turned dorsad and rolled inward, posterior half with numerous, sharp, posteriorly directed spines. Ductus bursae short, membranous, with small lateral pouch, expanded toward corpus bursae, bearing fine granulations, distinct spines absent. Corpus bursae about 1.5 times as long as wide; signum absent; surface finely scobinate (Fig. 23), each minute scobination borne on an irregular somewhat hexagonal plate; scobinations best developed on dorsal surface. Ductus seminalis arising dorsally from junction of corpus bursae and ductus bursae.

Type locality.—South Africa, roughly the region of the Transvaal and Orange Free State. Zeller (p. 46) cites the type locality as: "Patria ad fluvios Limpoponem et Gariepem." Gariep (Gareep) is an obsolete name which according to Skead (1973: 61, 171, 239) applied to both the lower and upper (above its junction with the Vaal) Orange River and to the lower Vaal River. Zeller's material came from Wahlberg, whose collecting localities in South Africa are imprecisely known. Horn and Kahle (1936: 293) record Wahlberg's first journey (1838–1845) there as to southern Africa, only later (1853) traveling to southwestern Africa. Therefore, it is probable that Zeller's reference to the Gariep applies to the upper (eastern) Orange or possibly to the lower Vaal, but not to the lower (western) Orange.

Lectotype, hereby designated, labelled: "Caffraria."; "436"; "Riksmuseum Stockholm"; "♀ genitalia on slide 1871 J. C. Shaffer"; "*Botys temeratalis* Lectotype by J. Shaffer & E. Munroe, 1989" [NHRM].

## *Notarcha muscerdalis* (Zeller)

NEW COMBINATION

Figs. 4, 8, 12, 24–27

*Botys muscerdalis* Zeller, 1852, pp. 43–44.

Diagnosis.—This species is distinguished externally from other African species of *Notarcha* by having a dark discal spot on an otherwise uniformly yellow forewing and internally by the presence of a signum on the corpus bursae.

Description (female).—Frons smooth, covered with appressed yellow scales. Labial palpus obliquely ascending, third segment short, subcylindrical; second and third segments uniformly yellow on outer sides, first segment similar distally, lighter basally; all segments devoid of dark spots. Maxillary palpus cylindrical, slender, extending to base of third segment of labial palpus; yellow. Antenna as in *N. quaternalis.* Ocellus well developed, with clear round lens on black elliptical base. Vertex yellow; occiput light yellow; patagium and tegula vivid yellow.

Forewing (Fig. 4) radius 12 mm; ground nearly uniformly yellow with a single large dark-brown elliptical, obliquely set discal spot.

Hindwing uniformly yellow.

Forecoxa brownish yellow; forefemur brown on inner side, light yellow on outer side; foretibia brownish yellow on basal half, brown on distal half; foretarsus with first segment yellow, second similar but with suggestion of brown at apex, third yellow on basal half, brown on distal half, fourth and fifth brown. Meso- and metathoracic legs nearly uniformly yellow.

Female genitalia (Figs. 24–27) with ovipositor compressed; lobes narrow, moderately setose. Anterior apophysis about 1.4 times as long as posterior, curved upward slightly, foliate at base; posterior apophysis with distal two-thirds straight. Ostial chamber well sclerotized, long and narrow, four times as long as central width, expanded slightly at posterior end; smooth, devoid of spines or setae. Ductus bursae with posterior one-third membranous, unarmed but for exceedingly minute widely spaced cusps; anterior two-thirds sclerotized, set with numerous minute cusps. Corpus bursae nearly round, slightly longer than wide, posterior end tapering to ductus bursae; surface finely scobinate (Fig. 25), each scobination in center of minute plate, roughly hexagonal to foliate; a single small longitudinal signum (Fig. 25) in center of corpus bursae, formed of several irregular longitudinal rows of small sclerotized papillae (Fig. 26). Ductus seminalis (Fig. 27) from extreme posterior end of corpus bursae, inner surface set with widely separated minute triangular cusps, devoid of setae.

Type locality.—South Africa, roughly the region of the Transvaal and Orange Free State. (Comment under *temeratalis* above applies here also.)

Lectotype, hereby designated, labelled: "Type"; "Botys muscerdalis Z. Caffr. 43. Led 85. Caffraria"; "Zell. Coll. 1884"; "♀ Pyralidae Brit. Mus. Slide No. 18061"; "*Botys muscerdalis* Lectotype by J. Shaffer & E. Munroe, 1989" [BMNH].

## ACKNOWLEDGMENTS

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# DESCRIPTION OF MALE *OSTROCERCA* RICKER (PLECOPTERA: NEMOURIDAE) USING THE SCANNING ELECTRON MICROSCOPE

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*Abstract.*—Scanning electron micrographs of the male terminalia are given for all six species of the stonefly genus *Ostrocerca* Ricker: *O. albidipennis* (Walker), *O. complexa* (Claassen), *O. dimicki* (Frison), *O. foersteri* (Ricker), *O. prolongata* (Claassen), and *O. truncata* (Claassen). Structures of the male genitalia previously not illustrated are described. Distribution records for each species are also reported.

*Key Words:* Stonefly, Plecoptera, Nemouridae, *Ostrocerca,* scanning electron micrographs

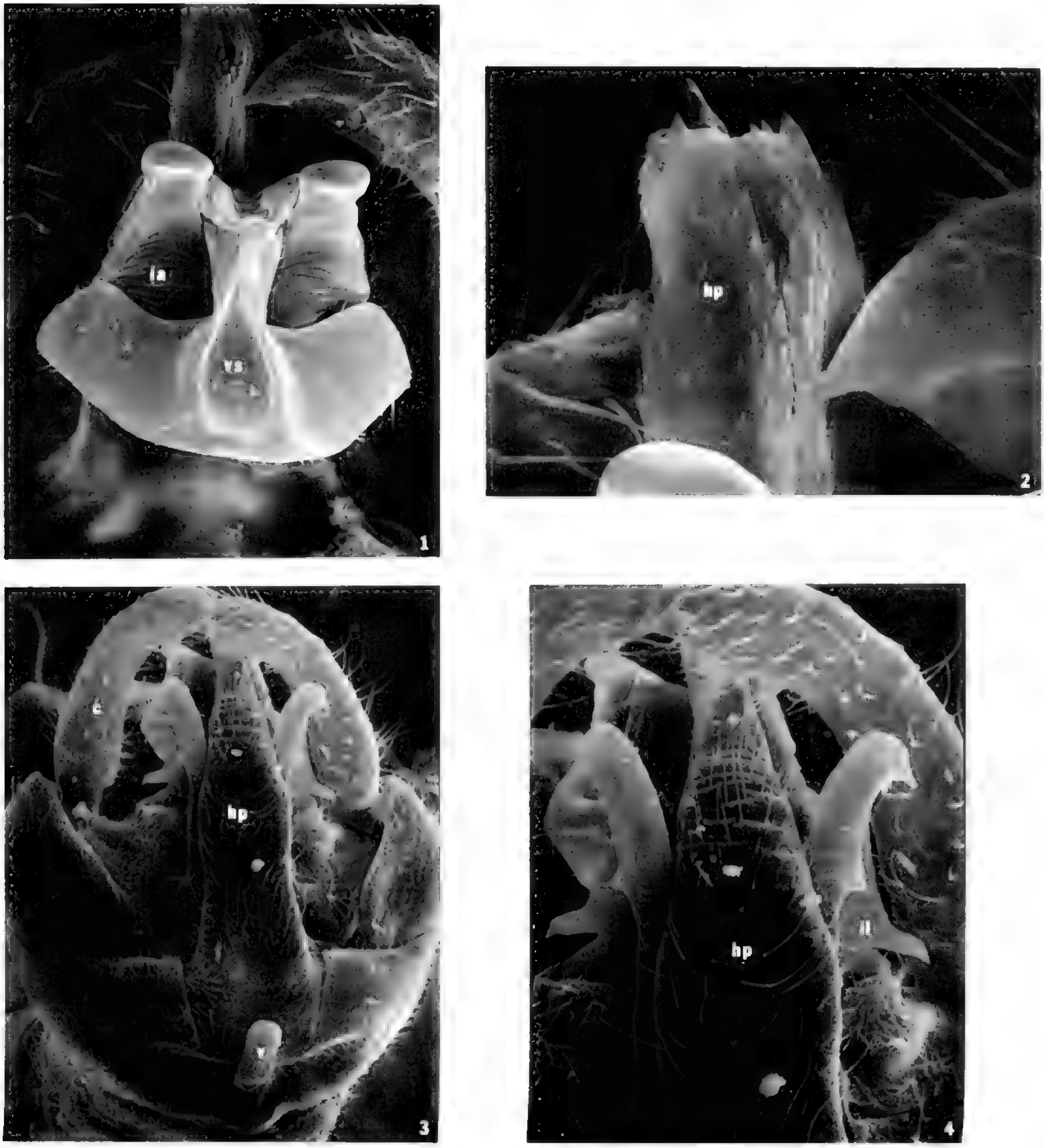
Scanning electron microscopy (SEM) has been used recently to elucidate fine structures of the male genitalia of stoneflies (Kondratieff and Kirchner 1984, Nelson and Baumann 1987). Newly recognized structures have been used in making determinations and preparing relationships.

The Nearctic genus *Ostrocerca* Ricker contains six species and is known for its small size (4–8 mm) and complex male genitalia (Ricker 1952). This genus occurs in eastern (four species) and northwestern (two species) North America (Stark et al. 1986). Nymphs usually inhabit crenon habitats, and adults are rare in collections, but can be collected by sweeping or beating.

Keys to males and females are provided by Ricker (1952) in his review of the genus and an updated key to females is given in his 1965 paper. Hitchcock's (1974) study enables the separation of the four eastern species. Baumann's (1975) generic description is based primarily on *O. truncata* Claassen. Our previous studies of specimens from Virginia (Kondratieff and Kirchner 1987) and West Virginia (Tarter and Kirchner 1980) showed that it is difficult to see the arrangement of structures of the complex epiproct with standard light microscopes. Using published illustrations, especially of the eastern species (Claassen 1923, Hitchcock 1974), it often appeared that additional taxa could be involved. Therefore, we used SEM to study the male genitalia of *Ostrocerca.* The higher magnification and greater depth of field in SEM made it possible to illustrate structures not previously recognized.

## METHODS AND MATERIALS

Specimens were prepared for study by removing them from 70–80% ethanol, submersing them in liquid Freon 12 at −154°C for several minutes, and then placing them into stored liquid nitrogen (−110°C to −80°C) and into a Balzers 301 Freeze-Fracture Unit at $10^{-6}$ mv. Specimens were then mounted and sputter coated with gold in a Hummer V Sputter Coater. Specimens were



Figs. 1–4. *Ostrocerca albidipennis.* 1, Epiproct, dorsal view, 312×. 2, Hypoproct, apex, 845×. 3, Terminalia, ventral view, 120×. 4, Terminalia, ventral view, 241×. Terms: hp, hypoproct; vs, ventral sclerite; la, lateral arms; il, inner lobe; c, cerci; v, vesicle.

viewed using a Phillips 505 SEM at 30,000 accelerating voltage.

The following institutions and individuals provided additional material for this study: R. W. Baumann, Brigham Young University, Monte L. Bean Life Science Museum (RWB); O. S. Flint, Jr., Smithsonian Institution, National Museum of Natural History (USNM); R. Foottit, Biosystematics Research Centre, Canadian National Collection (CNC); J. K. Liebherr, Cornell University (Cornell), Kathryn C. McGiffen, Illinois State Natural History Survey Division (INHS); C. Vogt, Museum of Comparative Zoology, Harvard University (MCZ); and J. R. Voshell, Jr., Virginia Tech.

Morphological terms of the following descriptions follow Baumann (1975). Baumann (1975) provides excellent illustrations of the male terminalia of *O. truncata*, clearly indicating the orientation of the structures of the male epiproct. Abbreviations used on the SEM photographs include hp, hypoproct; ds, dorsal sclerite; vs, ventral sclerite; la, lateral arms; ol, outer lobe; ml, middle lobe; il, inner lobe; c, cerci; and v, vesicle.

### *Ostrocerca albidipennis* (Walker)

*Nemoura albidipennis* Walker, 1852: 191. Type locality: Nova Scotia, Canada.
*Nemoura serrata* Claassen, 1923: 289. Type locality, Bar Harbor, (Hancock Co.) Maine; Ricker, 1952: 39 (syn.).
*Ostrocerca albidipennis,* Illies, 1966: 217.

The distinctive epiproct has a hammerhead shaped ventral sclerite, which is overlapped by the lateral arms of the dorsal sclerite (Fig. 1). The hypoproct is long and slender, and terminates in a complex serrate structure (Fig. 2). The paraprocts have inner lobes that are hooked medially and beaklike apically (Figs. 3 and 4). The figures presented by Claassen (1923) as *N. serrata* and by Hitchcock (1974) do not accurately depict these complicated structures.

The female is accurately illustrated by Hitchcock (1974) and by Ricker (1965).

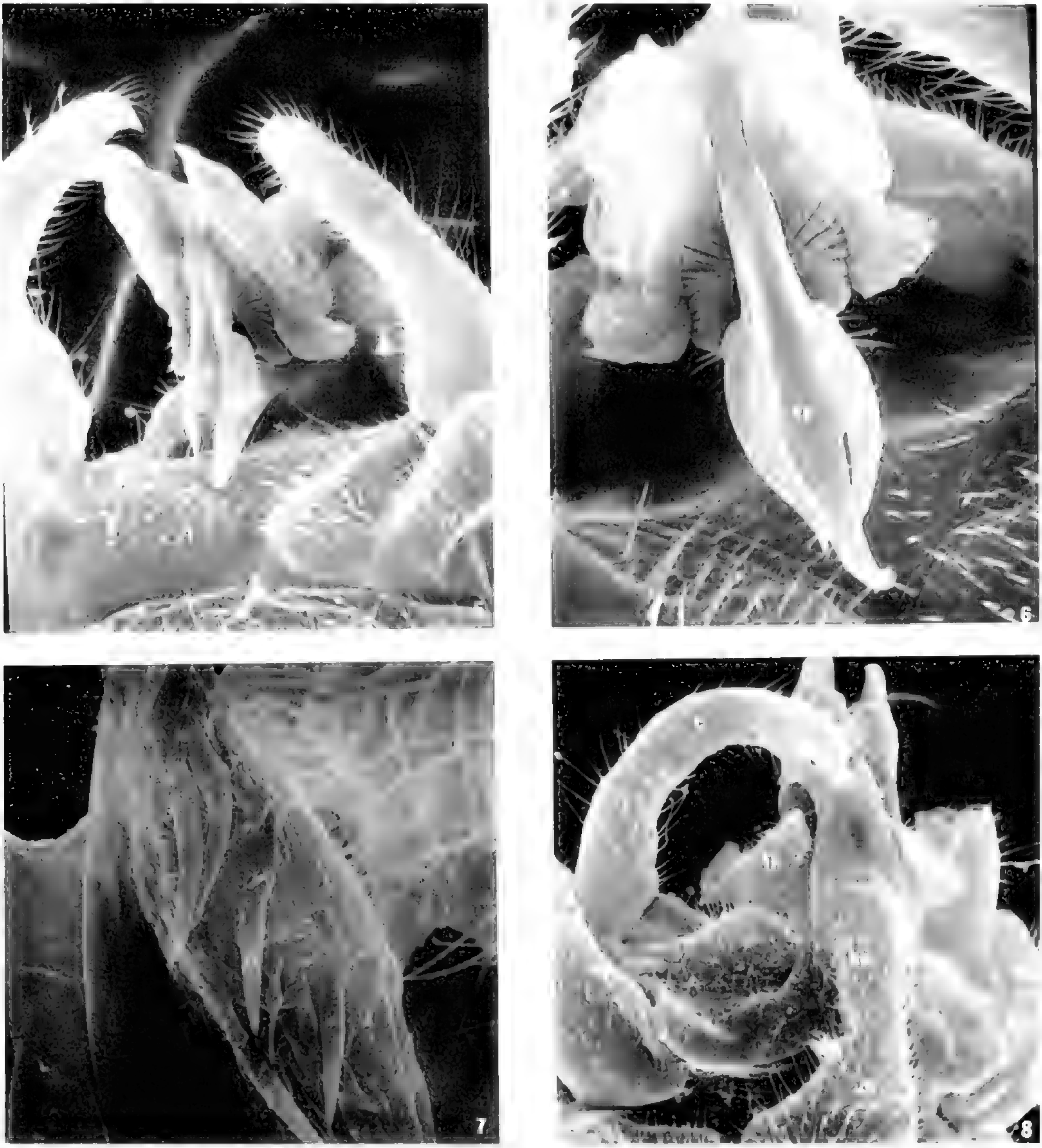
Material examined.—Holotype M (*N. serrata*), Bar Harbor, Maine, 8 VI 1921, C. W. Johnson (Cornell #1199). Paratype: same data as holotype, 1 M (Cornell #1199).

*Other specimens:* CANADA: Ontario, Algonquin Park, Costello Lake, 26 V 1938, W. M. Sprules, 1 M (INHS); same locality, 29 V 1939, 2 M (INHS); same locality, 26 V 1941, 1 M (INHS); Maynooth, Spring Creeks, 22 VI 1953, J. F. McAlpine, 2 M (CNC); Petawawa, Meridian Road, Forest Station, 28 V 1959, J. R. Vockeroth, 1 M, 1 F (CNC). Quebec, Harrington Lake, Gatineau Park, 27 V 1954, H. J. Huckel, 1 M, 6 F (CNC); Harrington Lake, 30 V 1954, E. E. Sterns, 3 M, 3 F (CNC); Wakefield, Lindsay's Creek, 31 V 1930, J. McDunnough, 1 M (CNC). CONNECTICUT: Naugatuck State Forest, Beacon Falls, 17 V 1961, S. W. Hitchcock, 5 M, 1 N (USNM). MAINE: on dropnet, (no locality) 4–14 VI 1970, D. E. Leonard, 4 M (USNM). MASSACHUSETTS: Whately, 18 V 1939, W. B. Nutting, 1 M, 4 F (USNM). NEW HAMPSHIRE: Warren, 21 VI 1941, T. H. Frison & H. H. Ross, 1 M (INHS). TENNESSEE: Cumberland Co., small stream, 2 mi. N of Adams Bridge, Obed River, Rt. 298, 13 V 1988, R. W. Baumann, C. R. Nelson, RFK & BCK, 1 M, 2 F (CSU). VERMONT: Mt. Hay Stack, 2400′, 28 V 1938, W. B. Nutting, 1 M (USNM). VIRGINIA: Giles Co., Mountain Lake, 2 VI 1962, J. R. Vockeroth, 2 F (CNC); Grayson Co., springs into Lewis Fork, Co. Rt. 603, 4 mi. W of Troutdale, 9–30 VI 1981, 16 M, 5 F, 3 N, RFK & BCK (RFK), 11 M, 9 F, 6 N BCK (VPI); Smyth Co., springs to Big Laurel Creek, Trail 166, Jefferson National Forest, 30 VI 1981, RFK & BCK, 2 F (RFK); Washington Co., spring to Brumley Creek, Clinch Mountain at Low Gap, Co. Rt. 690, 3600′, 23 VI 1981, RFK & BCK, 9 M, 6 F (RFK); Wise Co., Phillips Creek Rec. Area, N Fork Pound Reservoir, off Co. Rt. 671, 29 IV 1987, RFK & BCK, 1 M (BCK). WEST VIRGINIA: Pocahontas Co., Island Lick Run of Greenbriar R., Watoga State Park, Rt. 27, 16 VI 1981, RFK, 1 M (RFK); springs to Hills Creek, Rt. 39, Monongahela National Forest, 16 VI 1981, RFK, 1 M (RFK).

### *Ostrocerca complexa* (Claassen)

*Nemoura complexa* Claassen, 1937: 43. Type locality: Artists Brook, Essex County, New York.
*Ostrocerca complexa,* Illies, 1966: 217.

The elaborate epiproct (Figs. 5, 6) of this species has never been completely illustrat-



Figs. 5–8. *Ostrocerca complexa.* 5, Terminalia, dorsolateral view, 194×. 6, Epiproct, dorsal view, 212×. 7, Basal cushion of the dorsal sclerite, 965×. 8, Terminalia, ventral view, 163×. Terms: hp, hypoproct; vs, ventral sclerite; il, inner lobe; c, cerci; v, vesicle.

ed (see Claassen's 1937, Fig. 2 and Hitchcock's 1974, Fig. 107). The ventral sclerite is fork-like with a lower process that is elongate and apically recurved. The membranous basal cushion of the dorsal sclerite has five to six cuticular spine-like projections proximally and four to five distally (Fig. 7). These projections often appear membranous in SEM photomicrographs. The inner lobes of each paraproct are triangularly produced. The hypoproct is bifurcate apically (Fig. 8). The cerci are notched (Fig. 8).

The terminalia of the female are illustrated by Hitchcock (1974) and Ricker (1952, 1965).

Material examined.—Holotype M: Artists Brook, Essex Co., New York, 11 VI 1933, C. R. Crosby & H. Deitrich (Cornell #1692). Paratypes: same locality as holotype, 28 June 1923, P. W. Claassen, 1 M (Cornell #1692).

*Other specimens:* VERMONT: brooklet top of Brandon Gap, 2170′, 25 VI 1966, S. W. Hitchcock, 1 M (USNM). VIRGINIA: Nelson Co., tributary to South Fork Tye River, Montebello Fish Culture Station, jct. Rt. 690 & Rt. 56, 3 V 1980, BCK, 1 M, 2 F (VPI). WEST VIRGINIA: Pendleton Co., Spruce Knob, 4 mi. below summit, 16 V 1963, Field & O. S. Flint, 1 M (USNM); Pocahontas Co., springs to Hills Creek, 15 mi. E Richwood, Hills Creek Scenic Area, Rt. 39, Monongahela National Forest, 16 V 1981, RFK, 14 M, 6 F (RFK), same locality 15 V 1986, RFK & BCK, 2 M, 1 F (BCK); Tea Creek, Tea Creek Campground, Monongahela National Forest, 21 V 1978, RFK & R. M. Meyer, 1 M (RFK).

### ***Ostrocerca dimicki* (Frison)**

*Nemoura dimicki* Frison, 1936: 256. Type locality: Corvallis, Oregon.
*Ostrocerca dimicki,* Illies, 1966: 217.

This species is easily recognized by the hook-shaped ventral sclerite with erect setose processes (Figs. 9, 10, 11). The inner lobes of the hypoproct are robust and elongate, apically acute, and setose (Fig. 12). The hypoproct is broadly truncate apically and bears a medial sclerotized slender process (Fig. 12).

The female terminalia is illustrated by Ricker (1965).

Material examined.—Holotype M, Corvallis, Oregon, branch Dixon Creek, emerged 28 II 1935, R. W. Prentiss (INHS). Paratypes: Corvallis, drainage stream, 16 III 1934, E. E. Ball, 5 M (USNM); same data, 2 F (INHS); Corvallis, Brooklane Creek, 28 II 1935, R. W. Prentiss, 1 M (USNM).

*Other specimens:* CANADA: British Columbia, 30 V–18 VI 1955, R. Coyles, 1 M (CNC). OREGON: Washington Co., North Plains, 7 IV 1968, K. Goeden, 1 M, 2 F (USNM).

### ***Ostrocerca foersteri* (Ricker)**

*Nemoura foersteri* Ricker, 1943: 70. Type locality: Reservoir Creek, Cultus Lake, British Columbia.
*Ostrocerca foersteri,* Illies, 1966: 218.

The epiproct is simple (Figs. 13, 14), with the ventral sclerite knob-shaped and surrounded by the hook-like lateral lobes of the dorsal sclerite. The inner lobe of the paraprocts is slender and slightly hook-like (Fig. 14).

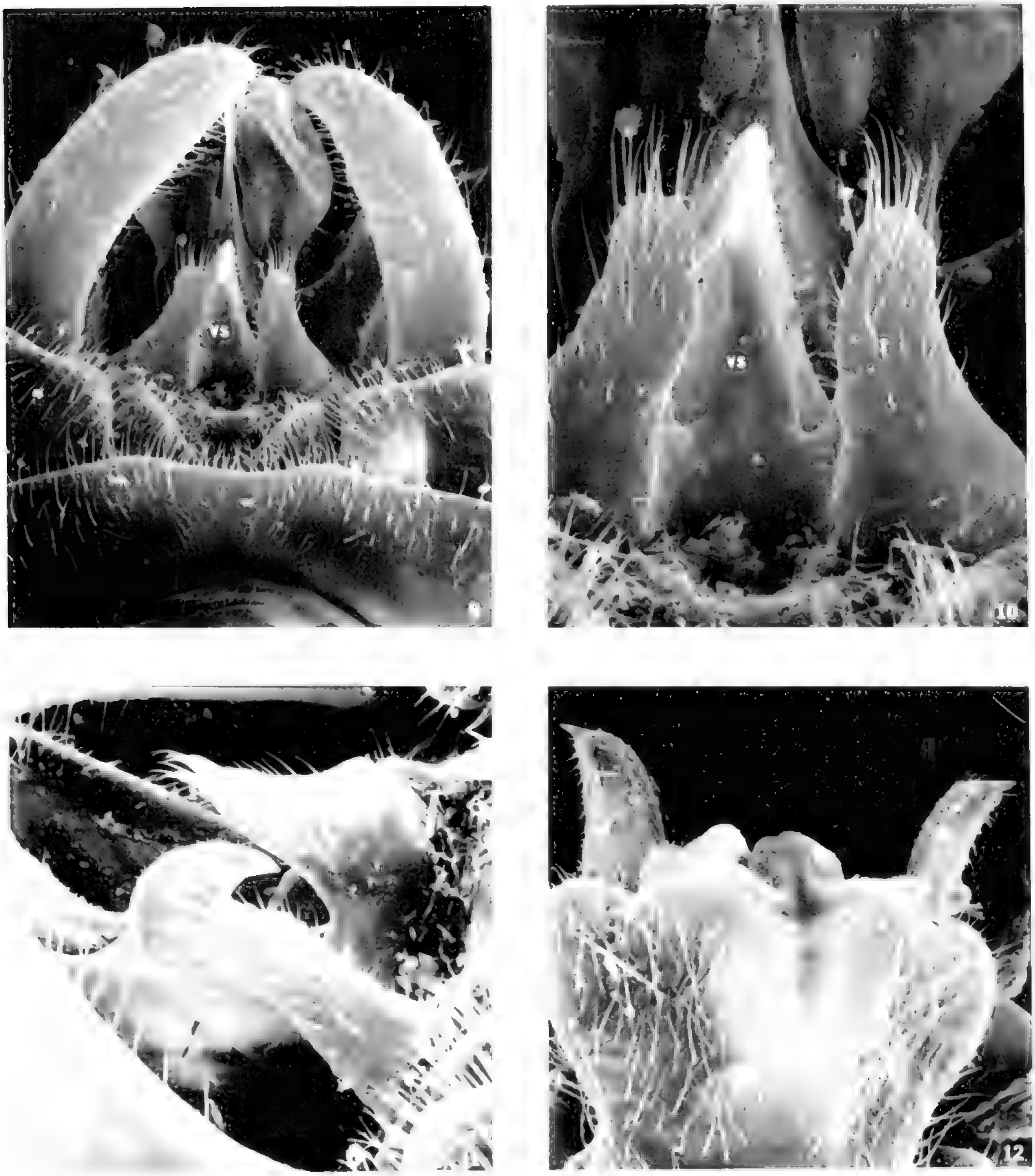
Material examined.—Paratype: Benton Co., Oregon, Rock Creek, Corvallis, 9 IV 1935, K. Grey, 1 M (INHS).

*Other specimens:* CANADA: British Columbia, Qualicum Bay, 15 V 1955, G. E. Shewell, 1 M, 11 F (CNC). CALIFORNIA: Humboldt Co., Willow Cr., Hwy 299, below Berry summit, 24 IV 1987, R. W. Baumann, C. R. Nelson, B. P. Stark & S. A. Wells, 6 M, 2 F (BYU). OREGON: Clatsop, Vic., Gronnel Road, ca. 2 mi. E Elsie, 1 IV 1967, S. G. Jewett, Jr., 7 M, 3 F (INHS); Douglas Co., 10 mi. E Gardner, 23 IV 1964, Vertrees & Schuh, 3 M, 13 F (USNM); Multnomah Co., Johnson Cr., trib. near SE 82 Ave., 8 III 1987, G. R. Fiala, 7 M (BYU).

### ***Ostrocerca prolongata* (Claassen)**

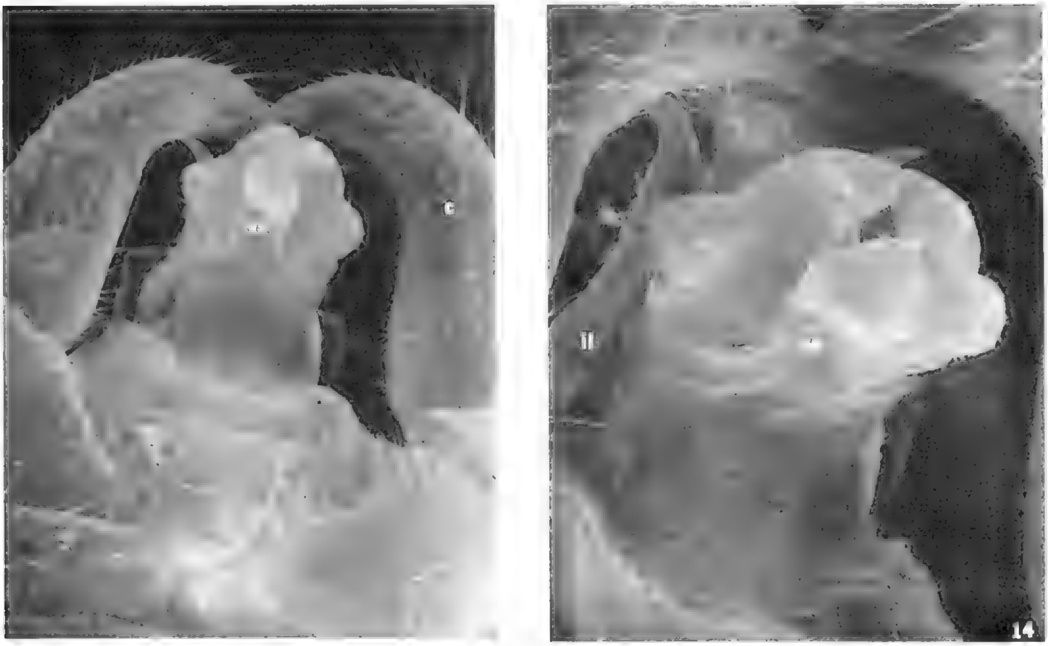
*Nemoura prolongata* Claassen, 1923: 289. Type locality: Bretton Woods, New Hampshire.
*Ostrocerca prolongata,* Illies, 1966: 218.

The complex ventral sclerite is characterized by two recurved erect processes and distally terminating in an elongate process (Figs. 15–18). The dorsal sclerite terminates into diverging lobes (Fig. 17). The inner lobes of the paraprocts are long and apically hooked (Figs. 19–21). The cerci are long and curved.



Figs. 9–12. *Ostrocerca dimicki.* 9, Terminalia, dorsal view, 163×. 10, Epiproct, dorsal view, 462×. 11, Ventral sclerite, lateral view, 356×. 12, Terminalia, ventral view, 120×. Terms: hp, hypoproct; vs, ventral sclerite; c, cerci; v, vesicle

The allotype female is badly damaged and the terminalia are missing. As Hitchcock (1974) points out, the female illustrated by Claassen (1923) may be misidentified. The subgenital plate (as illustrated), and venation is very similar to the sympatric *Soyedina washingtoni* (Claassen). Females found in collections with male *O. prolongata* ex-



Figs. 13–14. *Ostrocerca foersteri.* 13, Terminalia, dorsal view, 163×. 14, Terminalia, dorsal view, 462×. Terms: vs, ventral sclerite; il, inner lobe; c, cerci.

amined during this study were similar to females of *O. complexa* and *O. albidipennis.* And, because *Ostrocerca prolongata* was usually collected with the other two species, made positive association impossible. This species appears to be rare throughout its range.

Material examined.—Holotype M: Bretton Woods, New Hampshire, C. W. Johnson, 26 VI 1913 (MCZ). Paratype: Orono, Maine, 1 M (Cornell #1200). Allotype F: Orono, Maine (Cornell #1200).

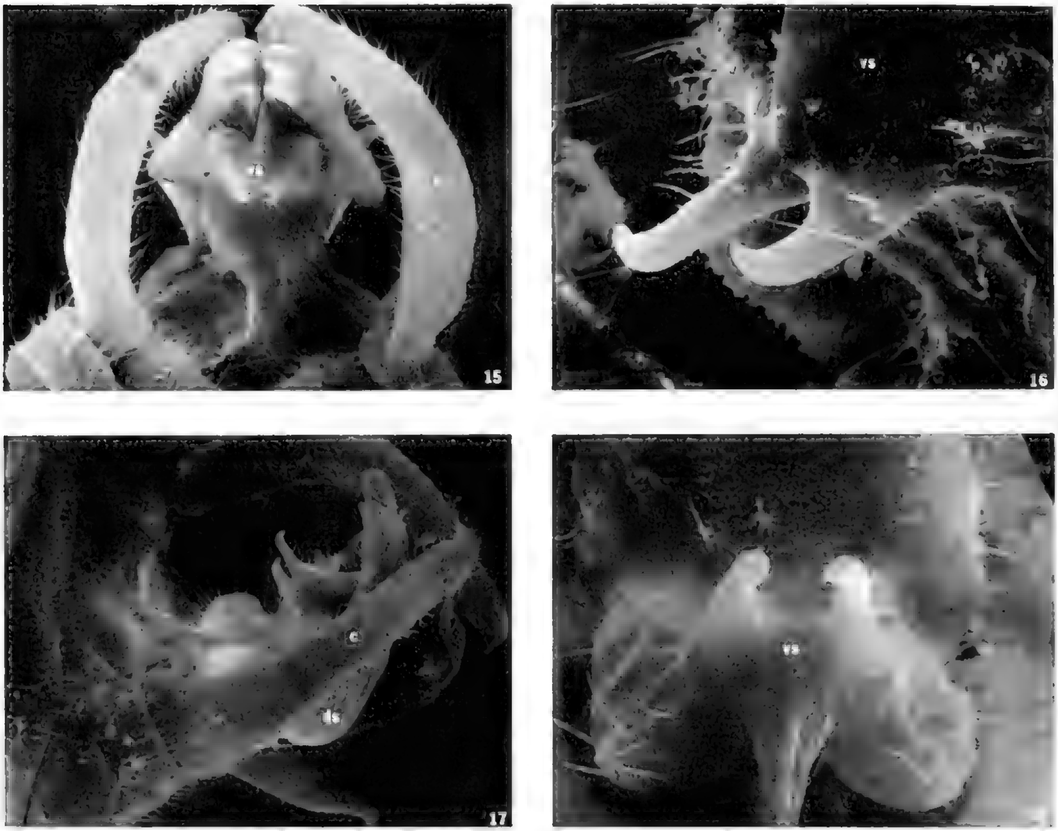
*Other specimens:* NEW HAMPSHIRE: Huntington Ravine, 4000′, 15 VIII 1935, C. P. Alexander, 1 M (USNM). NEW YORK: Heart Lake, Adirondacks, 2100′, 10 VII 1938, C. P. Alexander, 1 M (USNM). MAINE: on dropnet, no locality, 4–14 VI 1970, D. E. Leonard, 5 M (USNM). VIRGINIA: Nelson Co., small tributary of South Fork Tye River, Rt., 687, 3 V 1980, BCK, 2 M (VPI). WEST VIRGINIA: Tucker Co., Red Creek at Laneville, 26, 27 May 1973, O. S. Flint, 2 M (USNM).

### *Ostrocerca truncata* (Claassen)

*Nemoura truncata* Claassen, 1923: 290. Type locality, Walden, Massachusetts.
*Ostrocerca truncata,* Illies, 1966: 218.

This species is easily recognized by the bell-shaped ventral sclerite of the epiproct and thickened, short cerci (Figs. 22 and 23). The slender diverging inner lobes of the paraprocts are also distinctive (Figs. 24-25). The middorsal groove terminating in two sharp projections was not illustrated by Claassen (1923) (same illustrations used by Needham and Claassen, 1925) and Hitchcock (1974). Baumann (1975) illustration (Fig. 76) does not indicate the extent of these projections.

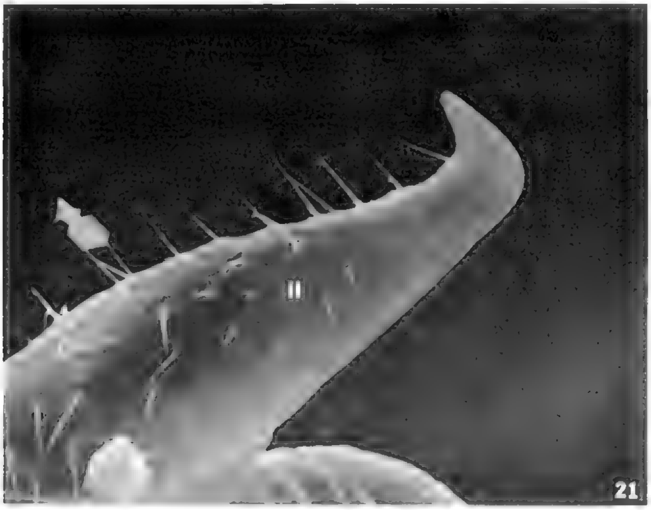
The female has been illustrated by Baumann (1975), Hitchcock (1974) and Ricker



Figs. 15–18. *Ostrocerca prolongata.* 15, Terminalia, dorsal view, 170×. 16, Process of ventral sclerite, 655×. 17, Terminalia, lateral view, 156×. 18, Ventral sclerite, bifurcate process, 356×. Terms: ds, dorsal sclerite; vs, ventral sclerite; c, cerci.

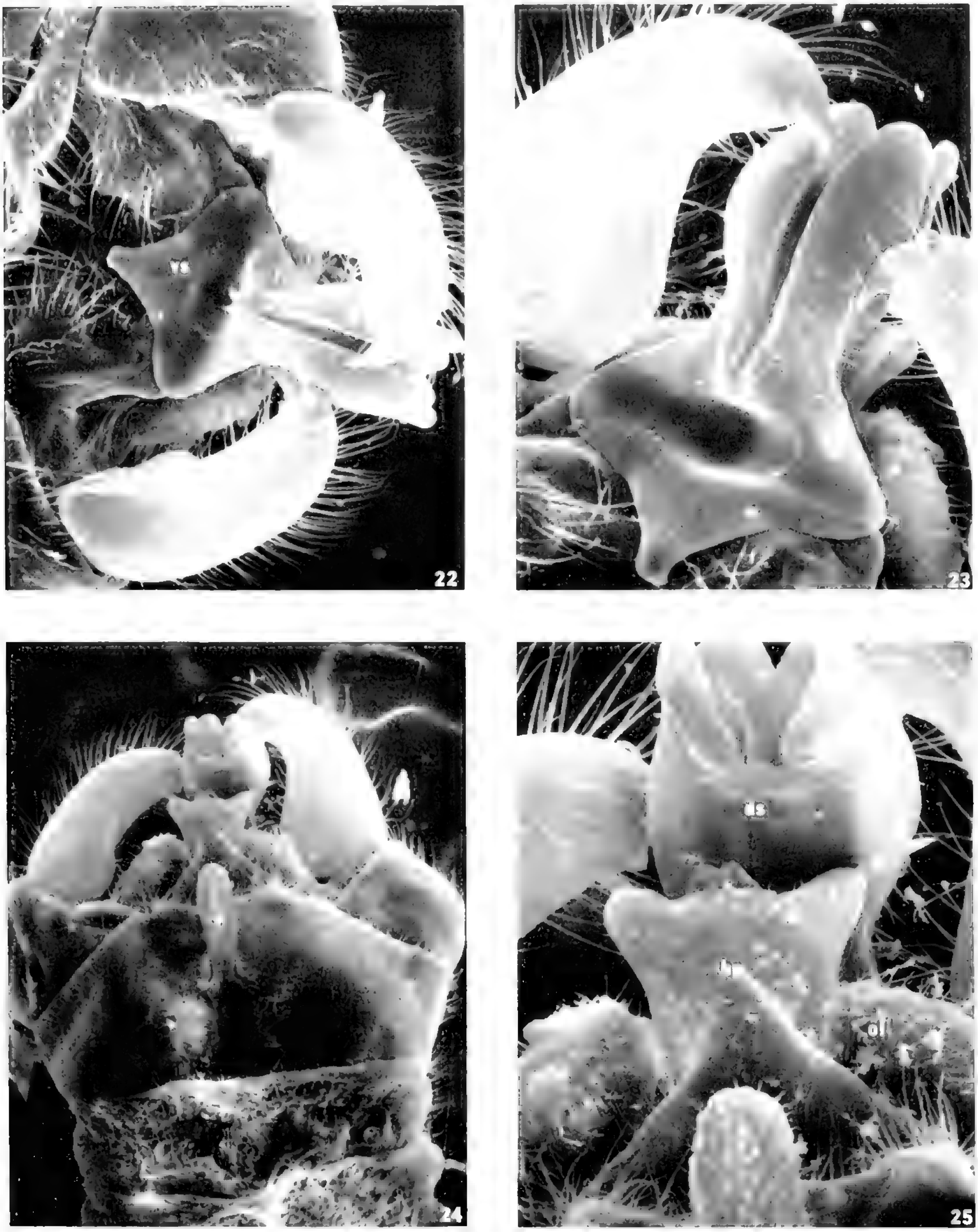
(1965). This species was once considered the rarest of the *Ostrocerca.* But, we found it to be common and widespread. The Alabama collection represents the southernmost extension of its range and is a new state record. The holotype of *Nemoura truncata* could not be located at the Museum of Comparative Zoology (C. Vogt, personal communication).

Material examined.—ALABAMA: DeKalb Co., spring seep, DeSoto State Park, River Trail, cabins 8 & 9, 17 V 1988, RFK & BCK, 1 F (BCK). CONNECTICUT: Beacon Falls, Naugatuck St. Forest, 17 VI 1961, S. W. Hitchcock, 1 M (USNM); Portland, 20 VI 1963, S. W. Hitchcock, 1 M (USNM); Newtown, 10 V 1962, S. W. Hitchcock, 3 M, 2 F (USNM). KENTUCKY: Bell Co., Stream at Pinnacle Rd. entrance, Cumberland Gap National Park, 10 IV 1971, R. A. Haick & C. R. Haick, 4 M, 8 N (USNM); Lawrence Co., Bridge Hollow of Hood Cr., 1.5 mi. S of Blaine Rt. 201, 20 IV 1984, RFK, 10 M (RFK). MASSACHUSETTS: Whately, Whately Glen, 18 V 1938, J. F. Hanson, 1 M (USNM); OHIO: Athens Co., Canaan Township, 25 IV 1941, J. Walker, 1 M (INHS). PENNSYLVANIA: York Co., spring seepage, Davidsburg, 5 mi. NW Woodland, 20 V 1962, P. J. Spangler, 12 M, 22 F, 12 N (USNM). VIRGINIA: Dickenson Co., spring seep into Hunts Creek,



Figs. 19–21. *Ostrocerca prolongata.* 19, Terminalia, lateral view, 137×. 20, Terminalia, ventral view, 106×. 21, Inner lobe of paraproct, 573×. Terms: hp, hypoproct; vs, ventral sclerite; il, inner lobe; c, cerci; v, vesicle.

Rt. 80, Breaks Interstate Park, 29 April 1987, RFK, BCK, 6 F (BCK); Tazwell Co., Station Springs Cr., Burkes Garden 3840′, off Rt. 666, 20 V 1982, RFK & BCK, 48 M, 14 F (RFK); Washington Co., spring to Brumley Cr., Clinch Mtn. at Low Gap, 3600′, Rt. 690, 23 V 1981, RFK & BCK, 15 M, 8 F (RFK); Wythe Co., Stony Fk. of



Figs. 22–25. *Ostrocerca truncata.* 22, Terminalia, dorsal view, 178×. 23, Epiproct, dorsal view, 263×. 24, Terminalia, ventral view, 120×. 25, Terminalia, ventral view, 356×. Terms: hp, hypoproct; ds, dorsal sclerite; vs, ventral sclerite; il, inner lobe; ol, outer lobe; c, cerci; v, vesicle.

Reed Cr., Dark Horse Hollow Rec. Area, Jefferson Nat. For., 29 IV 1978, RFK, 1 M (RFK). WEST VIRGINIA: Cabell Co., Lusher Hollow of Mud River, near Barboursville, US-60, 29-IV-1979, RFK, 4 M, 2 F (RFK); same locality 28 IV 1978, 4 M, 1 N (RFK); Greenbrier Co., Coats Run, Rt. 39, 26 IV 1987, RFK, BCK, 2 M (RFK); Logan Co., Trace Fork of Copperas Mine Fork, Holden, 15 IV 1973, RFK, 1 F (RFK); Pendleton Co., Spruce Knob, 4 mi. below summit, 16 V 1963, W D. Field & O. S. Flint, 1 M, 1 F (USNM); Pocahontas Co., Hills Cr., 15 mi. E of Richwood, Rt. 39, Monongahela NF, 20 V 1978, RFK, 2 F (RFK); East Fork Greenbrier River, Forest Rd., off Rt. 28, 26 IV 1987, RFK & BCK, 2 M (BCK); Tucker Co., Red Creek near Laneville, 26, 27 VI 1973, O. S. Flint, 1 M, 3 F (USNM).

## DISCUSSION

Examination of the males of *Ostrocerca* with SEM indicated that no taxonomic changes were necessary. However, the higher magnification and greater depth of field allowed for the first time a complete study of the male terminalia of all six species. The SEM micrographs elucidated structures of the epiproct previously not illustrated. For example, the distinctive fork-like ventral sclerite of *O. complexa* easily distinguishes this species; the serrate apex of the hypoproct is only found in *O. albidipennis*; and the ventral sclerite terminating in an elongate process is characteristic of *O. prolongata*. Consulting these micrographs will make it easier to identify male specimens using a dissecting microscope by confirming characters not illustrated or mentioned in original descriptions or redescriptions.

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# KEY TO THE KALOTERMITIDAE OF EASTERN UNITED STATES WITH A NEW *NEOTERMES* FROM FLORIDA (ISOPTERA)

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*Abstract.*—A new species of drywood termite of the genus *Neotermes* is described and figured, and an identification key is included to separate it from nine other kalotermitids from Florida. This species was first recognized as distinct from another morphologically very similar species, *Neotermes jouteli* (Banks), on the basis of karyotypic and isozymatic differences.

*Key Words:* *Neotermes,* Kalotermitidae, termites

Termites resembling *Neotermes jouteli* (Banks and Snyder) 1920 but differing from that species in chromosome number and isozyme patterns were recently noted by Dr. Peter Luykx during the course of a cytogenic survey of species of the family Kalotermitidae. We were requested to seek, and herewith report, morphometric features for characterizing this new taxon to make the name available for his research. Although we are confident that most of the termite species of the United States have been described, we find that refinements in taxonomic techniques are beginning to uncover complexes among already described species (Haverty and Thorne 1989, in press). When chromosomal, isozymatic, or behavioral studies are used in termite investigations, more species may be discovered in North America.

Samples were preserved in 85% ethanol; morphological features were measured with the device described in detail by Grant (1965). Measurements consisted of the following values in millimeters: *head length,* in lateral view, the distance from the left ventral mandibular condyle to the occiput; *head width,* in dorsal view, the greatest breadth at the genae; *head depth,* in lateral view, the distance between the vertex and the ventral margin of the head capsule; *eye diameter,* the width of the eye of the imago measured from its anterior to posterior margin; *postocular distance,* in dorsal view on the imago, the shortest distance from the midpoint of the occipital margin of the head to the imaginary line connecting the posterior margins of the compound eyes; *subocular distance,* in lateral view, the shortest distance connecting the ventral margin of a compound eye with the ventral margin of the head capsule; *ocellus length* and *width,* the greatest and shortest diameters, respectively, of the ocellus; *postmentum length,* the distance from the midpoint of the labial suture to the midpoint of the inner posterior margin of the postmentum; *postmentum width,* the minimum width of the postmentum at its constriction; *length* and *width* of *pronotum,* in dorsal view, the medial length and greatest width of the pronotum; *length* and *width* of *wing,* the total length of the forewing, including the scale, and the greatest width of the forewing; *total length,* in lateral view, the length of the body from the tip of the face to the apex of the abdomen; *length* of the *mandible,* in dorsal view, the length of the soldier mandible measured from the notch at the base of the outer mandibular condyle to the tip of the mandible (Tables 2, 4, 5).

Morphometric ratios found to have some value in identifying Florida kalotermitids included the following: *Head L/W,* the ratio of head length to head width; *Head L/D,* the ratio of head length to head depth; *Head W/D,* the ratio of head width to head depth; *Postocular distance/Eye diameter* and *Subocular distance/Eye diameter*; *Pronotum W/L,* the ratio of the greatest width to medial length of the pronotum; *Wing L/W,* the ratio of the wing length to wing width; *Wing L/Wingscale L,* and *Postmentum L/W* (Tables 3, 6, 7).

Except for a previously unidentified soldier and nymph in the National Museum Collection that had been collected by E. M. Miller in 1930, all of the material upon which this description is based was collected in south Florida by Peter Luykx. Specimens used in this study have been deposited in the following institutions: National Museum of Natural History, Smithsonian Institution, Washington, D.C. [NMNH], and the American Museum of Natural History, New York, NY [AMNH].

## DESCRIPTION

## *Neotermes luykxi* Nickle and Collins NEW SPECIES

Holotype.—Short-headed soldier. Florida: Broward Co. Dania. PL 389C. 30 June 1984. (Coll. P. Luykx). [NMNH]. Morphotype. Imago. Florida: Broward Co. Hollywood. PL 558. 21 August 1986. (Coll. P. Luykx). [NMNH].

Paratype series.—26 soldiers, 15 imagoes, 20 nymphs. Florida: Broward Co., Hollywood, PL 439, (P. Luykx), 6 soldiers, 5 imagoes, 4 nymphs [NMNH]; Same locality, PL 558 [morphotype sample], VIII-21-1986, 7 soldiers, 10 imagoes, 3 nymphs [NMNH, AMNH]; Florida: Broward Co., Dania, PL 389, VI-20-1984, (P. Luykx), 3 soldiers, 3 nymphs [NMNH]; PL 389C, same locality as PL 389, VI1984, 3 soldiers, 3 nymphs [NMNH]; Same locality, PL 400, VII-21-1984, (P. Luykx), 6 soldiers, 6 nymphs [NMNH, AMNH]; Florida: Dade Co., Key Largo, XII-6-1930, (Coll. E. M. Miller), 1 soldier, 1 nymph [NMNH].

Table 1. A list of chromosome numbers (2n) for Florida species of Kalotermitidae (Luykx and Syren 1979, Luykx pers. comm.).

| Species | Chromosome Number |
|---|---|
| *Calcaritermes nearcticus* | 29 (♂) |
| *Cryptotermes brevis* | 37 (♂), 36 (♀) |
| *Cryptotermes cavifrons* | 40 |
| *Incisitermes milleri* | 28 |
| *Incisitermes schwarzi* | 32 |
| *Incisitermes snyderi* | 44 |
| *Kalotermes approximatus* | 32 |
| *Neotermes castaneus* | 38 |
| *Neotermes luykxi* | 45 (♂), 44 (♀) |
| *Neotermes jouteli* | 56 |

Short-Headed soldier.—*Head:* 1.21× longer than wide, 1.46× longer than deep (Figs. 1E, 2E). From above, sides of head weakly convex, with greatest width at middle of head capsule. Labrum about as long as wide, broadly rounded. Antennal fossa oval; dorsal ridge well developed, extending over first article of antenna; ventral ridge weakly developed, lying flush with head capsule; from above, antennal fossa extending as a ridge to dorsal margin of clypeus. Antennae with 13 articles (rarely with 14), beadlike; article 1 broad, barrel shaped, equal in length to articles 2+3; article 2 smaller than 4; article 3 enlarged, subequal in length to 4+5; each successive article 4 through 13 similar in size, but becoming increasingly more elongated toward apex of antenna. Eyes comprised of a cluster of cells with central core darkly pigmented; eye

Table 2. TERMITE IMAGOES: means ($\bar{x}$) and ranges of measurements (in mm) of morphological features of *Neotermes*, *Incisitermes* and *Kalotermes* species. Numbers in parentheses after value indicate size of sample. NA = not available for measurement.

| | | *Neotermes castaneus* | *Neotermes jouteli* | *Neotermes luykxi* | *Kalotermes approximatus* | *Incisitermes snyderi* | *Incisitermes schwarzi* | *Incisitermes milleri* |
|---|---|---|---|---|---|---|---|---|
| # antennal articles | Range | 18 (5) | 18–20 (6) | 17–18 (8) | 16 (1) | 13–16 (8) | 18–19 (4) | NA |
| Head length | $\bar{x}$ | 1.59 (11) | 1.44 (6) | 1.31 (8) | 1.42 (4) | 1.07 (9) | 1.47 (4) | 0.86 (1) |
| | Range | 1.39–1.71 | 1.35–1.49 | 1.24–1.37 | 1.22–1.55 | 0.98–1.14 | 1.35–1.59 | |
| Head width | $\bar{x}$ | 1.81 (11) | 1.66 (6) | 1.46 (8) | 1.35 (4) | 1.19 (10) | 1.46 (3) | 0.84 (1) |
| | Range | 1.73–1.92 | 1.63–1.75 | 1.41–1.49 | 1.20–1.51 | 1.16–1.22 | 1.45–1.47 | |
| Head depth | $\bar{x}$ | 1.01 (8) | 0.94 (6) | 0.90 (8) | 0.84 (4) | 0.67 (10) | 0.95 (4) | 0.61 (1) |
| | Range | 0.98–1.06 | 0.92–0.96 | 0.86–0.92 | 0.75–0.90 | 0.63–0.69 | 0.94–0.96 | |
| Eye diameter | $\bar{x}$ | 0.46 (11) | 0.43 (6) | 0.37 (8) | 0.29 (4) | 0.32 (10) | 0.45 (4) | 0.24 (1) |
| | Range | 0.43–0.51 | 0.41–0.47 | 0.35–0.39 | 0.26–0.33 | 0.28–0.33 | 0.43–0.49 | |
| Postocular distance | $\bar{x}$ | 0.78 (11) | 0.63 (6) | 0.65 (8) | 0.76 (4) | 0.52 (10) | 0.73 (4) | 0.41 (1) |
| | Range | 0.69–0.90 | 0.51–0.71 | 0.57–0.77 | 0.63–0.86 | 0.43–0.55 | 0.69–0.79 | |
| Subocular distance | $\bar{x}$ | 0.33 (11) | 0.28 (6) | 0.22 (8) | 0.31 (4) | 0.16 (10) | 0.31 (4) | 0.16 (1) |
| | Range | 0.28–0.39 | 0.26–0.31 | 0.20–0.24 | 0.26–0.33 | 0.14–0.18 | 0.31–0.33 | |
| Ocellar L | $\bar{x}$ | 0.19 (11) | 0.15 (6) | 0.12 (8) | 0.10 (4) | 0.15 (10) | 0.18 (4) | 0.10 (1) |
| | Range | 0.16–0.24 | 0.14–0.16 | 0.12–0.14 | 0.60–0.12 | 0.12–0.16 | 0.16–0.20 | |
| Ocellar W | $\bar{x}$ | 0.14 (11) | 0.16 (6) | 0.15 (8) | 0.10 (4) | 0.10 (10) | 0.12 (4) | 0.08 (1) |
| | Range | 0.12–0.16 | 0.16 | 0.12–0.16 | 0.06–0.12 | 0.10–0.12 | 0.10–0.14 | |
| Width pronotum | $\bar{x}$ | 2.01 (11) | 1.86 (6) | 1.68 (7) | 1.61 (4) | 1.20 (10) | 1.73 (4) | 0.92 (1) |
| | Range | 1.71–2.45 | 1.77–1.92 | 1.59–1.69 | 1.51–1.67 | 1.14–1.22 | 1.69–1.79 | |
| Length pronotum | $\bar{x}$ | 1.09 (11) | 0.97 (6) | 0.91 (7) | 0.88 (4) | 0.67 (10) | 1.00 (4) | 0.57 (1) |
| | Range | 1.00–1.24 | 0.94–1.00 | 0.88–0.94 | 0.79–0.98 | 0.65–0.69 | 0.94–1.04 | |
| Total length | $\bar{x}$ | 8.66 (11) | 8.17 (6) | 7.28 (7) | 8.21 (4) | 5.32 (10) | 8.83 (4) | 5.58 (1) |
| | Range | 6.42–10.58 | 7.83–8.92 | 6.50–7.92 | 6.50–9.50 | 4.83–5.92 | 8.42–9.50 | |
| Wing length | $\bar{x}$ | 12.53 (8) | 11.15 (5) | 10.29 (7) | 7.83 (2) | 8.93 (6) | 11.89 (3) | NA |
| | Range | 11.58–13.75 | 11.00–11.25 | 9.92–10.83 | 7.83 | 8.83–9.00 | 11.25–12.92 | |
| Wing width | $\bar{x}$ | 3.42 (8) | 3.15 (5) | 2.73 (7) | 2.08 (2) | 2.36 (6) | 2.92 (3) | NA |
| | Range | 3.08–4.00 | 3.00–3.25 | 2.67–2.92 | 2.08 | 2.17–2.75 | 2.83–3.00 | |
| Wing scale length | $\bar{x}$ | 1.48 (11) | 1.13 (6) | 1.13 (7) | 1.21 (4) | 0.95 (10) | 1.20 (3) | 0.92 (1) |
| | Range | 1.17–1.92 | 0.83–1.33 | 1.08–1.25 | 1.08–1.25 | 0.83–1.08 | 1.17–1.25 | |

Table 3. TERMITE SHORT-HEADED SOLDIERS: means ($\bar{x}$) and ranges of measurements (in mm) of morphological features of *Neotermes*, *Kalotermes*, and *Insicitermes* species. Numbers in parentheses after value indicate size of sample. NA = not available for measurement.

| | | *Neotermes castaneus* | *Neotermes jouteli* | *Neotermes luykxi* | *Incisitermes snyderi* | *Incisitermes schwarzi* | *Incisitermes milleri* | *Kalotermes approximatus* |
|---|---|---|---|---|---|---|---|---|
| # antennal articles | Range | 16 (2) | 13–15 (10) | 13–14 (12) | 9–11 (2) | 13–14 (5) | 11 (3) | 14 (1) |
| Head length | $\bar{x}$ | 3.75 (10) | 2.26 (13) | 2.07 (17) | 2.03 (8) | 2.12 (5) | 1.84 (4) | 2.57 (3) |
| | Range | 3.50–4.25 | 2.08–2.83 | 1.75–2.10 | 1.96–2.17 | 2.00–2.25 | 1.83–1.87 | 2.50–2.62 |
| Head width | $\bar{x}$ | 2.85 | 1.86 (13) | 1.71 (17) | 1.38 (8) | 1.72 (5) | 1.02 (4) | 1.58 (3) |
| | Range | 2.67–3.04 | 1.71–2.25 | 1.58–1.92 | 1.37–1.42 | 1.67–1.79 | 1.00–1.04 | 1.58 |
| Head depth | $\bar{x}$ | 1.96 | 1.31 (13) | 1.20 (17) | 1.14 (8) | 1.26 (5) | 0.87 (4) | 1.36 (3) |
| | Range | 1.87–2.21 | 1.21–1.62 | 1.04–1.46 | 1.12–1.17 | 1.17–1.33 | 0.79–0.92 | 1.33–1.37 |
| Mandible length | $\bar{x}$ | 2.25 | 1.45 (13) | 1.40 (17) | 1.31 (8) | 1.47 (5) | 0.95 (4) | 1.48 (2) |
| | Range | 2.17–2.37 | 1.37–1.79 | 1.17–1.54 | 1.21–1.37 | 1.29–1.58 | 0.92–1.00 | 1.46–1.50 |
| Postmentum length | $\bar{x}$ | 2.62 | 1.51 (13) | 1.36 (17) | 1.44 (8) | 1.48 (5) | 1.36 (4) | 1.85 (3) |
| | Range | 2.12–3.08 | 1.42–1.87 | 1.08–1.79 | 1.37–1.54 | 1.42–1.54 | 1.33–1.42 | 1.71–1.92 |
| Postmentum width | $\bar{x}$ | 0.41 | 0.31 (13) | 0.31 (17) | 0.26 (8) | 0.27 (5) | 0.20 (4) | 0.28 (3) |
| | Range | 0.37–0.46 | 0.25–0.42 | 0.29–0.37 | 0.21–0.29 | 0.25–0.37 | 0.17–0.25 | 0.25–0.29 |
| Width pronotum | $\bar{x}$ | 2.59 | 2.04 (13) | 1.80 (17) | 1.31 (8) | 1.86 (5) | 0.94 (4) | 1.87 (2) |
| | Range | 2.46–2.87 | 1.87–2.46 | 1.58–2.12 | 1.29–1.37 | 1.71–1.96 | 0.83–1.04 | 1.83–1.92 |
| Length pronotum | $\bar{x}$ | 1.14 | 0.96 (13) | 0.82 (17) | 0.75 (8) | 0.82 (5) | 0.69 (4) | 0.47 (2) |
| | Range | 1.04–1.25 | 0.83–1.12 | 0.67–1.00 | 0.71–0.83 | 0.75–0.87 | 0.67–0.71 | 0.47 |
| Total length | $\bar{x}$ | 11.09 (8) | 8.05 (10) | 7.25 (6) | 5.53 (6) | 7.65 (5) | 5.98 (4) | 8.28 (3) |
| | Range | 10.67–11.58 | 7.00–9.08 | 6.92–7.67 | 5.17–7.17 | 6.75–7.92 | 5.42–6.42 | 7.83–8.58 |

Table 4. TERMINTE LONG-HEADED SOLDIERS: means ($\bar{x}$) and ranges of measurements (in mm) of morphological features of *Neotermes* and *Incisitermes* species from Florida. Numbers in parentheses after value indicate size of sample. NA = not available for measurement.

| | | *Neotermes castaneus* | *Neotermes jouteli* | *Neotermes luykxi* | *Incisitermes snyderi* | *Incisitermes schwarzi* | *Incisitermes milleri* |
|---|---|---|---|---|---|---|---|
| # antennal articles | Range | 16 (2) | 15–16 (6) | NA | 12 (2) | 13–15 (8) | 11 (1) |
| Head length | $\bar{x}$ | 3.75 (10) | 3.24 (6) | 3.14 (4) | 2.41 (2) | 3.57 (8) | 2.00 (2) |
| | Range | 3.50–4.25 | 3.04–3.42 | 3.00–3.42 | 2.37–2.46 | 3.21–3.92 | 2.00 |
| Head width | $\bar{x}$ | 2.85 (10) | 2.30 (6) | 2.00 (4) | 1.48 (2) | 2.13 (8) | 1.12 (2) |
| | Range | 2.67–3.04 | 2.04–2.46 | 1.96–2.04 | 1.46–1.50 | 1.96–2.21 | 1.12 |
| Head depth | $\bar{x}$ | 1.96 (10) | 1.67 (6) | 1.49 (4) | 1.23 (2) | 1.56 (8) | 1.02 (2) |
| | Range | 1.87–2.21 | 1.62–1.79 | 1.46–1.54 | 1.21–1.25 | 1.42–1.67 | 1.00–1.04 |
| Mandible length | $\bar{x}$ | 2.25 (10) | 1.84 (6) | 1.62 (4) | 1.37 (2) | 1.71 (8) | 1.06 (2) |
| | Range | 2.17–2.37 | 1.58–2.21 | 1.58–1.67 | 1.37 | 1.67–1.75 | 1.04–1.08 |
| Postmentum length | $\bar{x}$ | 2.62 (10) | 2.38 (6) | 2.34 (4) | 1.75 (2) | 2.75 (8) | 1.54 (1) |
| | Range | 2.12–3.08 | 2.04–2.58 | 2.12–2.50 | 1.75 | 2.42–3.12 | 1.54 |
| Postmentum width | $\bar{x}$ | 0.41 (10) | 0.48 (6) | 0.33 (4) | 0.29 (2) | 0.28 (8) | 0.19 (2) |
| | Range | 0.37–0.46 | 0.25–0.58 | 0.29–0.37 | 0.29 | 0.25–0.37 | 0.17–0.21 |
| Width pronotum | $\bar{x}$ | 2.59 (10) | 2.50 (6) | 2.16 (4) | 1.44 (2) | 2.33 (8) | 1.08 (1) |
| | Range | 2.46–2.87 | 2.29–2.71 | 2.12–2.25 | 1.42–1.46 | 2.17–2.50 | 1.08 |
| Length pronotum | $\bar{x}$ | 1.14 (10) | 1.21 (6) | 1.08 (4) | 0.89 (2) | 1.23 (8) | 0.79 (1) |
| | Range | 1.04–1.25 | 1.17–1.29 | 1.04–1.17 | 0.83–0.90 | 1.12–1.33 | 0.79 |
| Total length | $\bar{x}$ | 11.09 (8) | 9.68 (6) | NA | NA | 10.72 (8) | 6.83 (1) |
| | Range | 10.67–11.58 | 8.75–10.75 | | | 10.08–11.25 | |

cluster situated a distance of less than diameter of cluster from antennal fossa. Mandibles ⅔ as long as head capsule; in lateral view, curving upward anteriorly; mandible dentition and shape of postmentum as in Fig. 1E.

*Thorax:* Pronotum broader than head capsule. Anterior margin broadly concave but not incised; posterior margin weakly notched medially. Range of greatest width/medial length 2.04–2.37.

*Legs:* Femora inflated, 2.3–2.5× longer than wide. Tibial spurs 3:3:3. Arolia absent.

*Color:* Mandibles glossy black. Head capsule reddish-brown anteriorly, becoming more yellowish-brown along posterior margin. Antennae light reddish-brown, darker basally. Labrum reddish-brown; clypeus translucent or whitish. Eyes purplish-gray. Body and legs whitish-yellow.

Imago morphotype.—*Head:* In dorsal view, head length from base of mandibles 0.78–0.83× as long as head width just behind compound eyes. Compound eyes 0.35–0.39 mm in diameter; subocular distance ca. 0.62× diameter of compound eye; postocular distance ca. 1.78× diameter of compound eye. Compound eye separated from antennal socket by less than 0.1 mm. Ocelli oval, with greatest diameter 0.15 mm; separated from compound eye by less than ocellar diameter. Antenna with 18 articles, 2.1–2.3 mm in length, ca. 1.7× longer than head length to base of mandibles.

*Thorax:* Pronotum 1.87× broader than long; anterior margin broadly concave; posterior margin medially notched.

*Legs:* Femora slightly enlarged or inflated, 2.6–2.8× longer than wide. Tibial spurs 3:3:3. Arolia present.

*Wings:* Hyaline, yellowish with brown anterior veins. Venation as in all *Neotermes*, with M nearly as sclerotized as Rs, running closer to Rs than to Cu. Length of forewing 9.9–10.8 mm ($\bar{x}$ = 10.3 mm), 3.77× longer than its greatest width (Fig. 3B).

Table 5. Ratios of morphological features of imagoes of *Kalotermes*, *Neotermes*, and *Incisitermes* termites from Florida. Numbers in parentheses after value indicate size of sample. NA = not available for measurement.

| | | *Neotermes castaneus* | *Neotermes jouteli* | *Neotermes luykxi* | *Kalotermes approximatus* | *Incisitermes schwarzi* | *Incisitermes snyderi* | *Incisitermes milleri* |
|---|---|---|---|---|---|---|---|---|
| Head L/W | $\bar{x}$ | 0.88 (11) | 0.86 (6) | 0.81 (8) | 1.05 (4) | 1.00 (3) | 0.89 (9) | 1.02 (1) |
| | Range | 0.73–0.93 | 0.82–0.91 | 0.83–0.96 | 1.01–1.13 | 0.92–1.09 | 0.83–0.96 | |
| Head L/D | $\bar{x}$ | 1.51 (11) | 1.52 (6) | 1.46 (8) | 1.69 | 1.54 (4) | 1.61 (9) | 1.40 (1) |
| | Range | 1.38–1.61 | 1.40–1.59 | 1.39–1.52 | 1.62–1.77 | 1.41–1.66 | 1.47–1.81 | |
| Head W/D | $\bar{x}$ | 1.75 (11) | 1.76 (6) | 1.64 (8) | 1.62 | 1.53 (3) | 1.79 (10) | 1.37 (1) |
| | Range | 1.65–1.94 | 1.70–1.83 | 1.55–1.74 | 1.55–1.72 | 1.51–1.56 | 1.68–1.87 | |
| Pstoc. D/Eye Dia. | $\bar{x}$ | 1.68 (11) | 1.44 (6) | 1.78 (8) | 2.55 | 1.62 (3) | 1.63 (10) | 1.71 (1) |
| | Range | 1.48–2.00 | 1.25–1.57 | 1.55–2.11 | 2.38–2.67 | 1.60–1.65 | 1.40–1.93 | |
| Suboc. D/Eye Dia. | $\bar{x}$ | 0.72 (11) | 0.66 (6) | 0.62 (8) | 1.04 | 0.70 (4) | 0.53 (10) | 0.66 (1) |
| | Range | 0.61–0.86 | 0.59–0.71 | 0.53–0.70 | 0.93–1.15 | 0.63–0.77 | 0.44–0.57 | |
| Pronotum W/L | $\bar{x}$ | 1.83 (11) | 1.91 (6) | 1.87 (7) | 1.84 | 1.73 (4) | 1.79 (10) | 1.61 (1) |
| | Range | 1.56–2.07 | 1.85–1.96 | 1.84–1.95 | 1.71–1.95 | 1.68–1.80 | 1.70–1.87 | |
| Wing L/W | $\bar{x}$ | 3.60 (8) | 3.55 (5) | 3.77 (7) | 3.76 (2) | 4.07 (3) | 3.80 (6) | NA |
| | Range | 3.32–4.13 | 3.43–3.67 | 3.60–4.06 | 3.76 | 3.94–4.30 | 3.21–4.11 | |
| WingL/WingScale | $\bar{x}$ | 7.83 (8) | 10.12 (5) | 9.11 (7) | 6.75 (2) | 9.94 (3) | 9.29 (6) | NA |
| | Range | 7.00–10.46 | 8.37–13.60 | 8.40–9.69 | 6.27–7.23 | 9.64–10.33 | 8.23–10.28 | |

Table 6. Ratios of morphological features of long-headed soldier termites from Florida. Numbers in parentheses after value indicate size of sample. NA = not available for measurement.

| | | *Neotermes castaneus* | *Neotermes jouteli* | *Neotermes luykxi* | *Incisitermes snyderi* | *Incisitermes schwarzi* | *Incisitermes milleri* |
|---|---|---|---|---|---|---|---|
| Head L/W | $\bar{x}$ | 1.32 (10) | 1.42 (6) | 1.57 (4) | 1.63 (2) | 1.78 (8) | 1.78 (2) |
| | Range | 1.22–1.41 | 1.27–1.65 | 1.50–1.67 | 1.63–1.64 | 1.60–1.84 | 1.78 |
| Head L/D | $\bar{x}$ | 1.91 (10) | 1.94 (6) | 2.12 (4) | 1.96 (2) | 2.29 (8) | 1.89 (2) |
| | Range | 1.83–2.09 | 1.82–2.08 | 2.06–2.21 | 1.96–1.97 | 2.22–2.46 | 1.78–2.00 |
| Head W/D | $\bar{x}$ | 1.45 (10) | 1.37 (6) | 1.35 (4) | 1.20 (2) | 1.37 (8) | 1.10 (2) |
| | Range | 1.38–1.51 | 1.26–1.45 | 1.32–1.37 | 1.20–1.21 | 1.27–1.43 | 1.08–1.12 |
| Head L/Mandible L | $\bar{x}$ | 1.67 (10) | 1.77 (6) | 1.93 (4) | 1.76 (2) | 2.08 (8) | 1.88 (2) |
| | Range | 1.53–1.89 | 1.55–2.13 | 1.89–2.05 | 1.73–1.79 | 1.88–2.35 | 1.85–1.92 |
| Pronotum W/L | $\bar{x}$ | 2.28 (10) | 2.07 (6) | 2.00 (4) | 1.61 (2) | 1.89 (8) | 1.37 (2) |
| | Range | 2.03–2.44 | 1.83–2.21 | 1.93–2.04 | 1.48–1.75 | 1.74–2.00 | 1.37 |
| Postment. L/min. W | $\bar{x}$ | 6.41 (10) | 4.62 (5) | 7.09 (4) | 6.00 (2) | 8.04 (8) | 8.32 (2) |
| | Range | 5.18–7.11 | 3.77–6.02 | 6.37–8.57 | 6.00 | 6.44–9.37 | 7.40–9.25 |

*Color:* Head, pronotum, legs, and tergites of abdomen uniformly yellowish; clypeus whitish-yellow; labrum same color as head capsule. Sternites lighter yellow than tergites.

*Variation:* Twenty-two soldier paratypes are short-headed forms and four are long-headed forms (Figs. 1B, E and 2D, E). Although all have pigmented eyespots, the degree of pigmentation varies from light to dark grey, and in some specimens they appear purplish. Both soldier forms vary in size (Tables 3, 4). Although there are no overlaps in most measurements between soldier forms, the largest short-headed and smallest long-headed soldiers share the same values for head depth, postmentum width, and pronotum width. Among morphometric ratios for identification of soldier forms, only Head W/D overlaps in the two forms (Tables 6, 7). Imago paratypes also vary in size (Tables 2, 5).

Diagnosis.—*Soldier:* We recognize *luykxi* as a species of *Neotermes* on the basis of the shape of the pronotum, which is not deeply incised as in species of *Incisitermes*. Of the Florida species of *Neotermes, luykxi* and *jouteli* are more closely related and are easily distinguished from *castaneus* (Burmeister 1839), a species with only one form of soldier. *Neotermes castaneus* is larger, has a slightly broader head as seen in dorsal view (Fig. 2A–C), and has unpigmented eyespots. Mandible dentition may also help to separate these species (Fig. 4B). *Neotermes luykxi* and *N. jouteli* both have pigmented eyespots and resemble one another in the head shapes of long- and short-headed soldiers. The L/W ratio for short-headed soldiers of both *N. jouteli* and *N. luykxi* is 1.21; for long-headed soldiers, the ratio is 1.42 for *N. jouteli* and 1.57 for *N. luykxi*. The L/W ratio for *N. castaneus* is 1.32. The long-headed soldier of *N. luykxi* usually has both a narrower head and a longer, narrower postmentum than *N. jouteli*. Although *N. luykxi* is generally smaller than *N. jouteli*, there is overlap for all measurements in soldiers of the same head form, and the mean values reflect only trends for each species (See Tables). The most significant difference between the two species is chromosome number (45[♂] 44[♀] for *N. luykxi*, 56 [both sexes] for *N. jouteli*) (Table 1). The morphometric difference that seems to be most useful in differentiating these two species is the ratio of the postmentum length to its minimum width. For short-headed soldiers this ratio is 4.41 for *N. luykxi* and 4.98 for *N. jouteli*. For long-headed soldiers it is 7.09

Table 7. Ratios of morphological features of short-headed soldier termites from Florida. Numbers in parentheses after value indicate size of sample available for measurement. NA = not available for measurement.

| | | *Neotermes jouteli* | *Neotermes luykxi* | *Incisitermes snyderi* | *Incisitermes schwarzi* | *Incisitermes milleri* | *Kalotermes approximatus* |
|---|---|---|---|---|---|---|---|
| Head L/W | $\bar{x}$ | 1.21 (13) | 1.21 (17) | 1.46 (8) | 1.23 (5) | 1.80 (4) | 1.62 (3) |
| | Range | 1.16–1.39 | 1.10–1.31 | 1.42–1.57 | 1.19–1.32 | 1.72–1.87 | 1.58–1.66 |
| Head L/D | $\bar{x}$ | 1.77 (13) | 1.72 (17) | 1.78 (8) | 1.68 (5) | 2.11 (4) | 1.91 (3) |
| | Range | 1.59–2.43 | 1.60–1.84 | 1.71–1.86 | 1.59–1.80 | 2.00–2.14 | 1.87–1.97 |
| Head W/D | $\bar{x}$ | 1.42 (13) | 1.42 (17) | 1.21 (8) | 1.37 (5) | NA | 1.16 (3) |
| | Range | 1.36–1.54 | 1.31–1.52 | 1.18–1.26 | 1.28–1.43 | | 1.15–1.19 |
| Head L/Mandible L | $\bar{x}$ | 1.53 (13) | 1.51 (17) | 1.53 (8) | 1.44 (5) | 1.94 (4) | 1.73 (2) |
| | Range | 1.39–1.84 | 1.38–1.73 | 1.42–1.62 | 1.30–1.64 | 1.87–2.00 | 1.71–1.75 |
| Pronotum W/L | $\bar{x}$ | 2.15 (13) | 2.20 (17) | 1.75 (8) | 2.26 (5) | 1.36 (4) | 1.95 (2) |
| | Range | 1.95–2.54 | 2.04–2.37 | 1.55–1.88 | 2.05–2.44 | 1.25–1.47 | 1.91–2.00 |
| Postmentum L/min. W | $\bar{x}$ | 4.98 (13) | 4.41 (17) | 5.57 (8) | 4.33 (5) | 7.17 (4) | 6.70 (3) |
| | Range | 4.22–5.83 | 3.71–6.14 | 4.71–6.80 | 4.25–4.62 | 5.67–8.00 | 5.85–7.67 |

for *N. luykxi,* 4.62 for *N. jouteli,* and 6.41 for *N. castaneus. Neotermes luykxi* and *N. jouteli* also differ in isozyme composition (Luykx et al., in prep.).

*Imago:* Assignment of the imago of *N. luykxi* to *Neotermes* was made on the basis of wing venation and length of the anterior margin of the second marginal tooth of the left mandible. Differentiating the three Florida species of *Neotermes* depends primarily upon a comparison of all morphometric features listed in Tables 2 and 5, none of which by itself is useful in identifying an individual specimen. *Neotermes luykxi* is the smallest of the three species, however, and the diameter of its compound eye is consistently smaller. The presence of long setae on the head and pronotum is a diagnostic character; *N. castaneus* generally has long setae on the head and pronotum, while *N. jouteli* and *N. luykxi* have only scattered short setae (Fig. 6A–I). Wing length, wing scale length, and head width are generally largest for *N. castaneus* and smallest for *N. luykxi* (Tables 2, 5).

Discussion.—Morphologically, *Neotermes jouteli* is most similar to this new species, but Luykx et al. (in prep.) found that the chromosome number (2n) of *N. jouteli* was 56 [both sexes] and only 45 [♂] and 44 [♀] for *N. luykxi.* Luykx also found interspecific differences in a series of isozymes among five selected kalotermitids (including *N. jouteli* and *N. luykxi*).

It has become increasingly common to identify sibling species of animals by using chromosomal differences. Once phena have been segregated on the basis of such differences, it is usually possible to identify morphological characters which are helpful in distinguishing the forms. Such was the case with a European mole cricket, *Gryllotalpa septemdecimchromosomica* Ortiz (1958), and more recently with a complex of other sibling species of *Gryllotalpa*: *quindecim, sedecim, octodecim,* and *viginti* (Baccetti and

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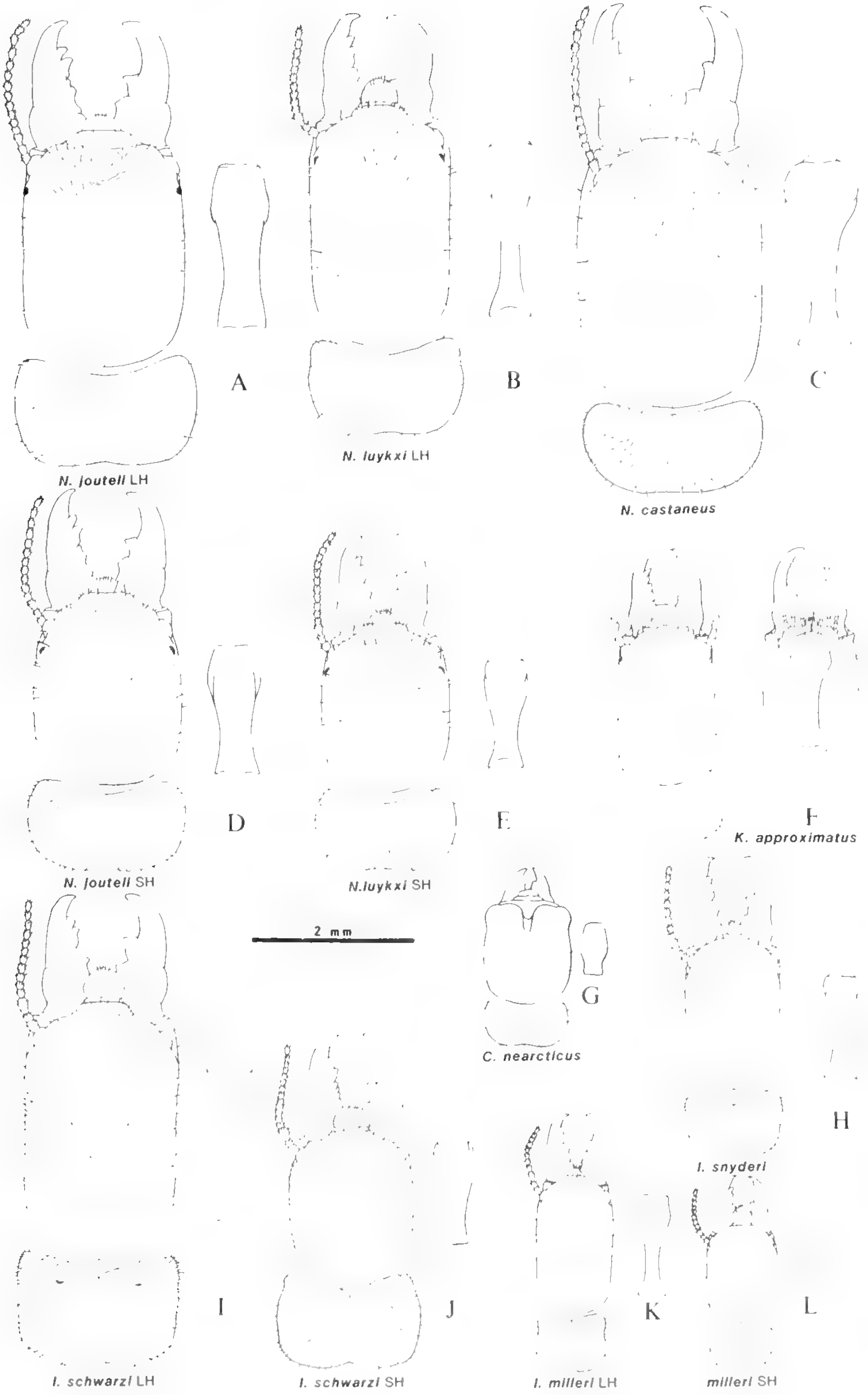
⟶

Fig. 1. Termite soldiers, head and pronotum, dorsal view. Also figured beside each soldier head: postmentum, ventral view. A, *Neotermes jouteli,* long-head (LH); B, *N. luykxi,* LH; C, *N. castaneus*; D, *N. jouteli,* short-head (SH); E, *N. luykxi,* SH; F, *Kalotermes approximatus*; G, *Calcaritermes nearcticus*; H, *Incisitermes snyderi*; I, *I. schwarzi,* LH; J, *I. schwarzi,* SH; K, *I. milleri,* LH; L, *I. milleri,* SH.


A
N. joutell LH
B
N. luykxi LH
C
N. castaneus
D
N. joutell SH
E
N.luykxi SH
F
K. approximatus
2 mm
G
C. nearcticus
H
I. snyderi
I
I. schwarzi LH
J
I. schwarzi SH
K
I. milleri LH
L
milleri SH

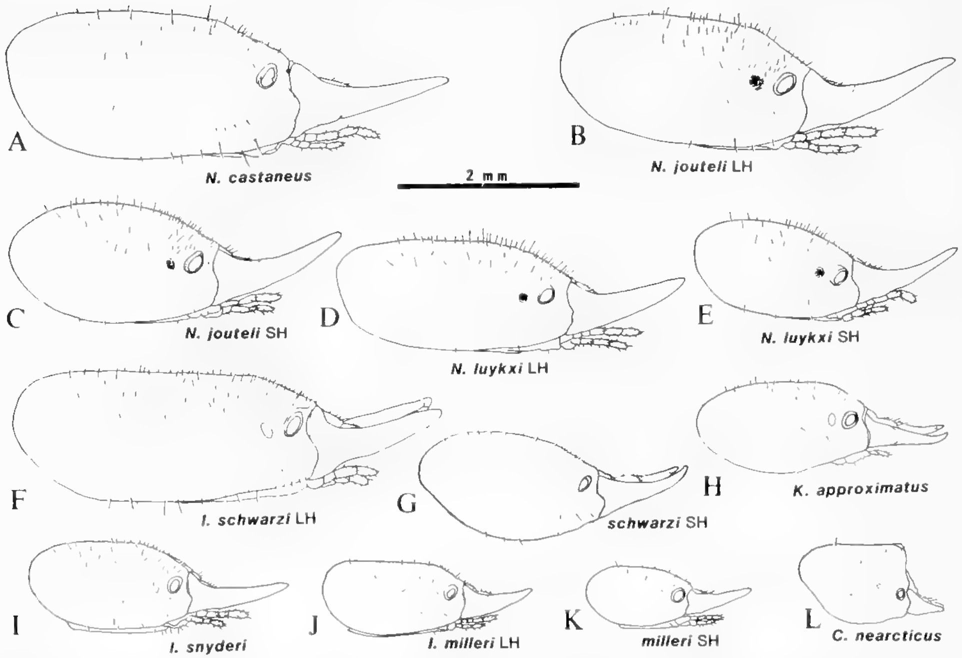


Fig. 2. Termite soldiers, head profile. A, *Neotermes castaneus*; B, *N. jouteli*, long-head (LH); C, *N. jouteli*, short-head (SH); D, *N. luykxi*, LH; E, *N. luykxi*, SH; F, *Incisitermes schwarzi*, LH; G, *I. schwarzi*, SH; H, *Kalotermes approximatus*; I, *I. snyderi*; J, *I. milleri*, LH; K, *I. milleri*, SH; L, *Calcaritermes nearcticus*.

Capra 1978). These species, otherwise morphologically very similar to *Gryllotalpa gryllotalpa* (L.), have chromosome complements of 17, 15, 16, 18, and 14, respectively, compared with 12 for *G. gryllotalpa*. Once it was determined that different chromosomal numbers occurred within the complex, it was possible to establish morphometric parameters of the variable characters for each species.

As in *Incisitermes milleri* (Emerson), *I. snyderi* (Light), *I. schwarzi* (Banks), and *Neotermes jouteli, N. luykxi* soldiers occur as long-headed or as short-headed forms. Short-headed forms are usually more common than long-headed ones within most samples we have seen. The different head forms probably result from differences in the stage of nymphal development when soldier differentiation occurs. Grassé and Noirot (1958) demonstrated that young *Kalotermes flavicollis* (F.) colonies developed soldiers from 2nd and 3rd instar larvae, while older colonies developed soldiers from 4th and 5th instar larvae.

There are five genera of drywood termites in the eastern United States: *Calcaritermes* (*nearcticus* (Snyder 1933)), *Cryptotermes* (*cavifrons* Banks 1906 and *brevis* (Walker 1853)), *Incisitermes* (*snyderi, schwarzi*, and *milleri*), *Kalotermes* (*approximatus* Banks and Snyder 1920), and *Neotermes* (*castaneus, jouteli*, and the new species *luykxi*). All of these species are known to occur in Florida.

*Kalotermes approximatus* is not usually economically important, except in rare cases when it becomes locally abundant. It is generally associated with dead wood in sand dunes in northern Florida, Alabama, Mississippi, and Louisiana, and northward along the coastal plain into southern Virginia. Weesner (1965) reported this species in homes in Waco, Texas, in 1957 and 1958

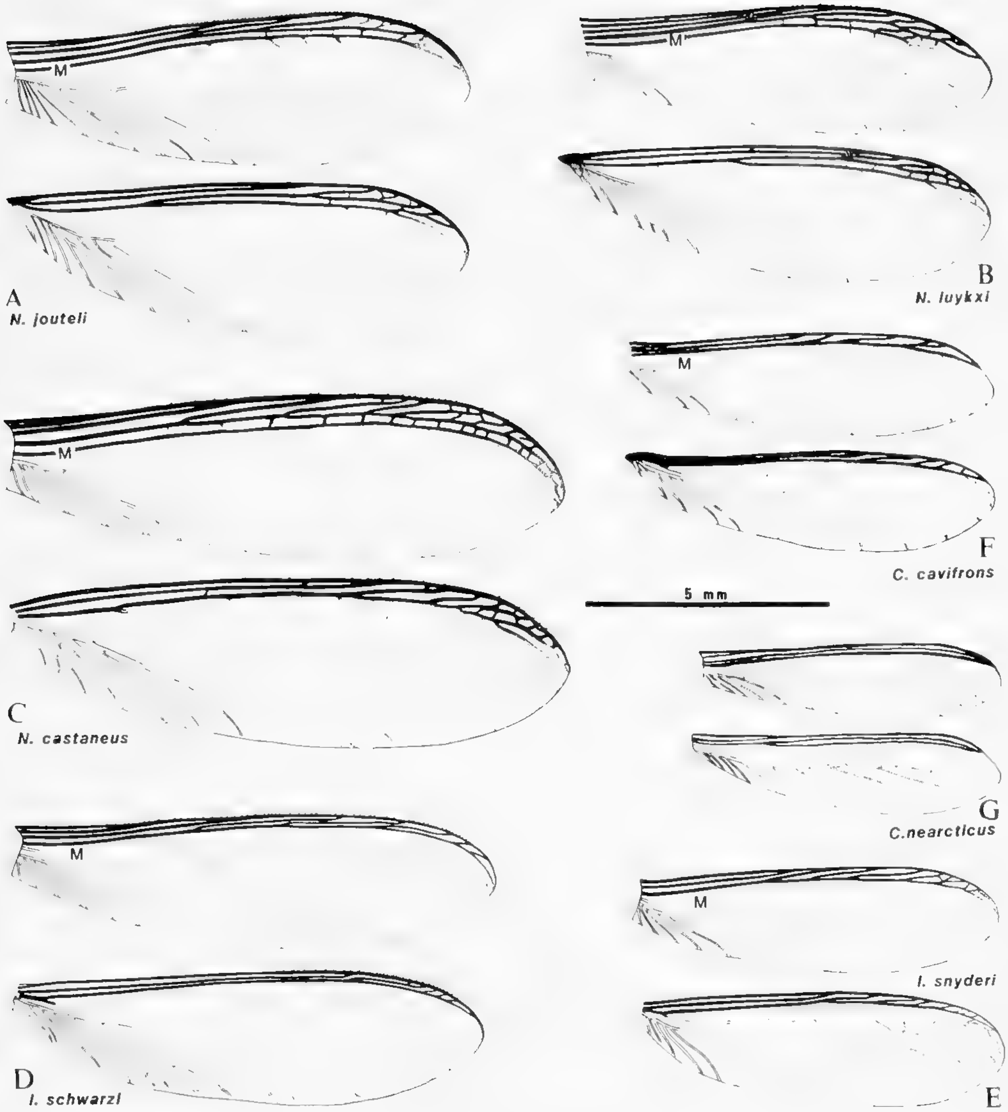


Fig. 3. Wings of alates of kalotermitids. A, *Neotermes jouteli*; B, *N. luykxi*; C, *N. castaneus*; D, *Incisitermes schwarzi*; E, *I. snyderi*; F, *Cryptotermes cavifrons*; G, *Calcaritermes nearcticus*. (M = medius vein.)

according to National Pest Control Association Records, but we have no specimens to confirm its presence in that state.

The two genera of kalotermitids most likely to be encountered in southern Florida are *Neotermes* and *Incisitermes*. *Neotermes jouteli* occurs in southern Florida, Jamaica, the West Indies, and Mexico. *Neotermes castaneus* occurs in southern Florida, West Indies, Central and South America. *Neotermes luykxi* is presently known only from Monroe, Dade, and Broward Counties, Florida. *Neotermes* species tend to be more moisture-dependent than those of *Incisitermes* (Collins 1969). *Neotermes jouteli* may enter man-made structures, infesting wet wood or wood that becomes wet from time to time. *Neotermes castaneus* also has been

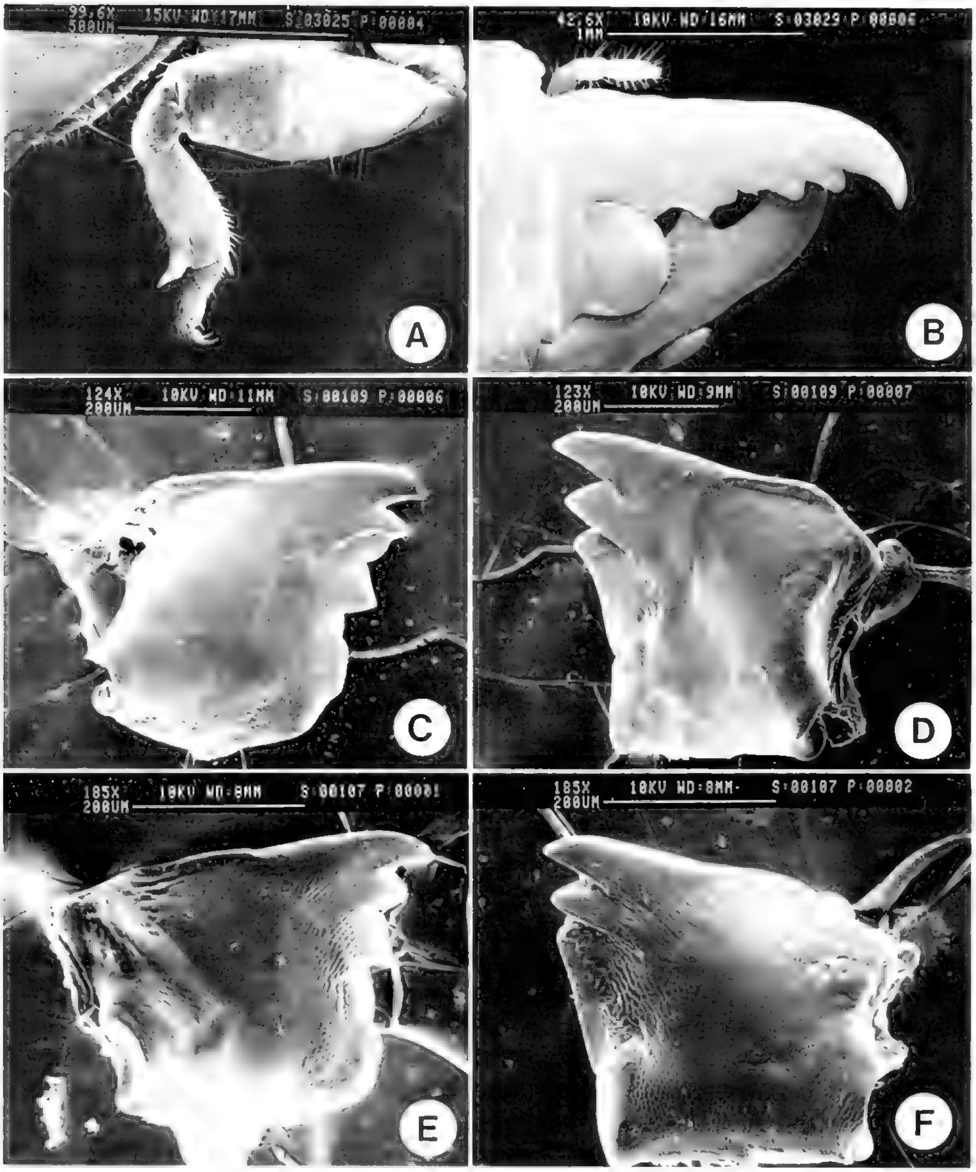


Fig. 4. Scanning electron micrographs of morphological features of kalotermitid termites. A, *Calcaritermes nearcticus*, apex of left foretibia, lateral aspect. B, *Neotermes castaneus* soldier, left mandible, dorsal aspect. C, D, *Neotermes castaneus*, imago mandibles: C, left, D, right. E, F, *Cryptotermes brevis*, imago mandibles: E, left, F, right.

recorded as a pest of avocado, guava, and citrus trees in south Florida and other parts of its range, attacking dead wood of injuries and then invading adjacent living parts of the trees (Miller 1949, Araujo 1970).

*Incisitermes snyderi* is widespread along the Coastal Plain from Texas to Florida and northward to South Carolina and in Central America and several islands in the Caribbean. It occurs commonly in dead cypress (*Taxodium* spp.) in the United States, causing extensive damage to untreated wood and

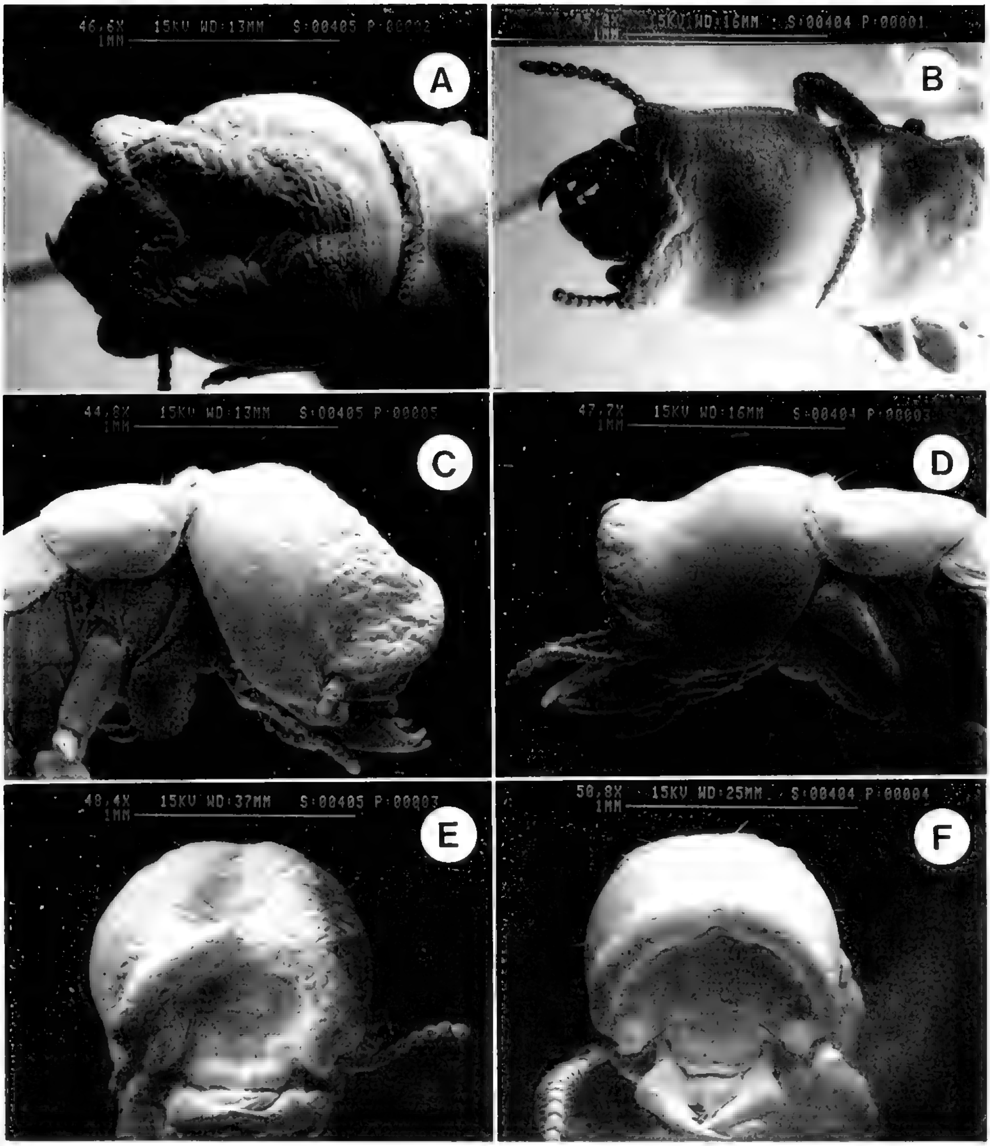
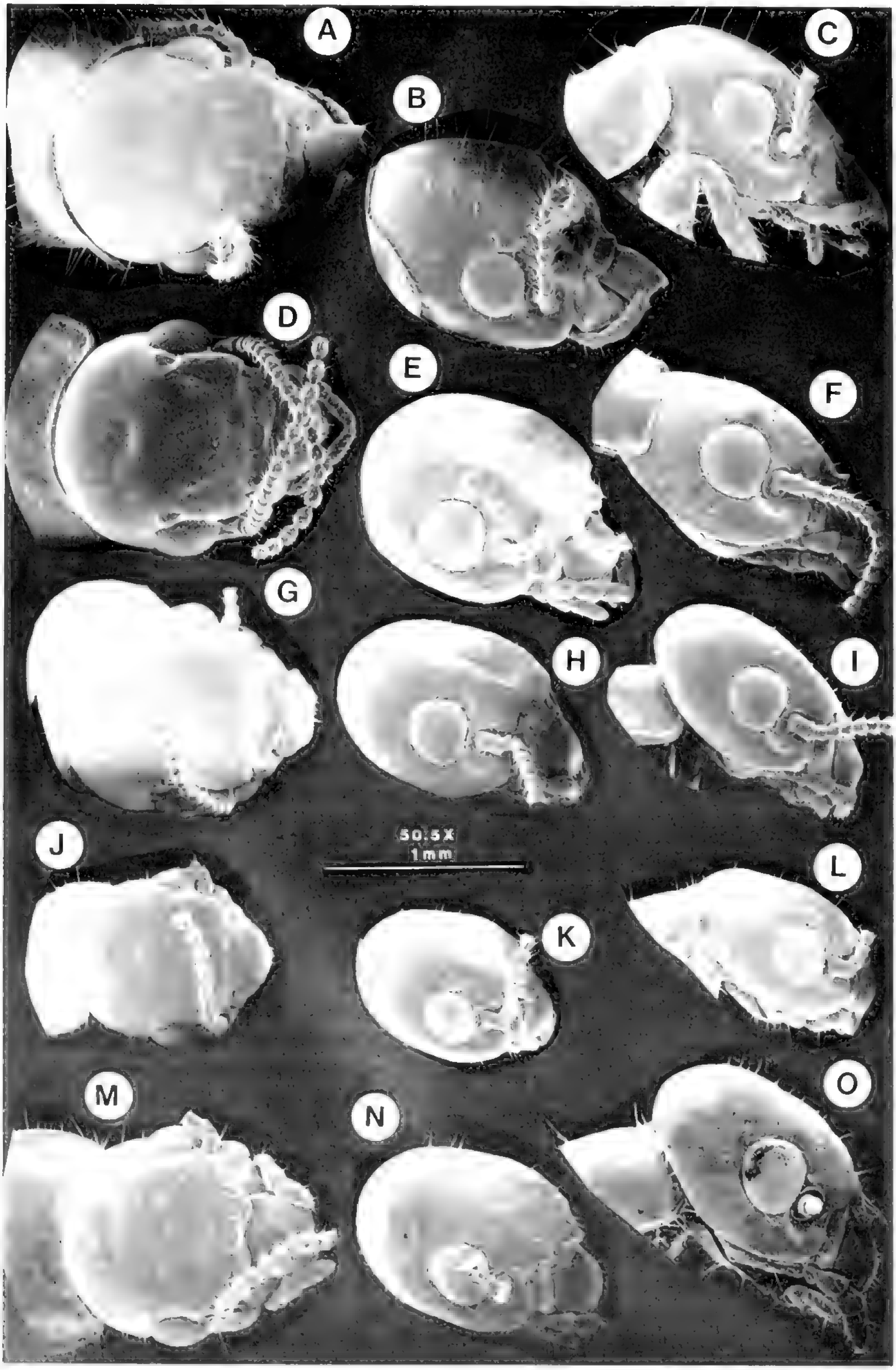


Fig. 5. Scanning electron micrographs of morphological features of kalotermitid termites. A, C, E. *Cryptotermes brevis*, soldier: A, dorsal, C, lateral, E, frontal aspect. B, D, F. *Cryptotermes cavifrons*, soldier: B, dorsal, D, lateral, F, frontal aspect.

fence posts (Miller 1949). *Incisitermes schwarzi*, found commonly in south Florida, also occurs in eastern Mexico (Yucatan) and throughout the West Indies. Like *Neotermes jouteli*, *I. schwarzi* is found in habitats with more available moisture and higher temperatures than *I. snyderi*. *Incisitermes milleri* is known only from the forested areas of the Florida Keys and Jamaica and is found in the sound wood of dead stumps.

The remaining drywood termites in this region all have soldiers with phragmotic (stopper-like) heads. *Calcaritermes* has nu-


A
B
C
D
E
F
G
H
I
50.5X
1mm
J
K
L
M
N
O

merous species in the Neotropics but only a single species, *nearcticus* (Banks 1918), in the United States. *Calcaritermes nearcticus* is found in natural habitats in northern Florida but has not yet been recorded from man-made structures. In contrast, termites of the genus *Cryptotermes* are major pests. *Cryptotermes cavifrons* has been found in natural habitats throughout peninsular Florida, islands of the Caribbean and Central America (Araujo 1977), but *Cryptotermes brevis,* the more important pest species of the two, is known only from the dry wood of man-made structures in the United States and elsewhere in the world. It is a common household pest from North Carolina through Florida to Texas and is frequently found in furniture, picture frames, and other wooden items that have been transported to northern states from areas of infestation in the South and other warm regions of the world.

The following identification key resolves some of the difficulties in determining termites from the eastern United States.

## Key to the Ten Species of Kalotermitidae Occurring in Eastern United States

### IMAGOES

1. Anterior edge of second marginal tooth of left mandible elongated, longer than straight line transect of posterior edge of first marginal tooth (Fig. 4E) .......... 2
– Anterior edge of second marginal tooth of left mandible not elongated, subequal in length to straight line transect of posterior edge of first marginal tooth (Fig. 4C) .......... 6
2. Media (M) of forewing running midway between radial sector (Rs) and cubitus (Cu) and extending to apex of wing (Fig. 3D, E) [*Incisitermes*] .......... 3
– Media (M) of forewing curving anteriorly and joining radial sector at about two-thirds length of wing from suture (Fig. 3F) [*Cryptotermes*] .......... 5
3. Body length 7–8 mm; body dark brown .......... *Incisitermes milleri*
– Body length greater than 10 mm, but usually not exceeding 16 mm; body yellow to yellowish brown .......... 4
4. Body length 15–16 mm; yellow-brown; wing length (including wing scale) greater than 10 mm (Fig. 3D); head shape as in Fig. 6M–O .......... *Incisitermes schwarzi*
– Body length 10–12 mm; yellowish; wing length less than 10 mm (Fig. 3E); head shape as in Fig. 6J–L .......... *Incisitermes snyderi*
5. Body length 10–12 mm; head width behind eyes greater than 1.0 mm; antenna usually with 16–18 articles .......... *Cryptotermes brevis*
– Body length less than 10 mm; head width less than 1.0 mm; antenna usually with fewer than 16 articles .......... *Cryptotermes cavifrons*
6. M vein of forewing unsclerotized, located midway between Rs and Cu; compound eye less than 0.35 mm in diameter; ocellus less than 0.12 mm in diameter; head length/width ratio greater than 1.0; body sooty black; wings shorter than body .......... *Kalotermes approximatus*
– M vein of forewing nearly as sclerotized as Rs, located closer to Rs than to Cu; without other above combination of characters .......... 7
7. Rs and M of forewing close together, without crossveins; Cu equidistant between M and anal margin (Fig. 3G) .......... *Calcaritermes nearcticus*
– Rs and M of forewing wider apart, with several crossveins extending from Rs to costal border; Cu closer to M than to anal margin (Fig. 3C) [*Neotermes*] .......... 8
8. Body length 15–16 mm; wing length greater than 12 mm; wing dark brown; forewing with numerous crossveins between Rs and M (Fig. 3C); body darkly pigmented; head and pronotum usually with both long and short setae (Fig. 6A–C) .......... *Neotermes castaneus*
– Body length less than 15 mm; wing length 9.0–11.5 mm; wing clear or only slightly pigmented; forewing with a few crossveins between Rs and M (Fig. 3A, B); body golden or yellow; head and pronotum with short setae only (Fig. 6D–I) .......... 9
9. Mean total body length 8.1 mm (range 7.8–9.0

←

Fig. 6. Scanning electron micrographs of morphological features of kalotermitid termites. A, B, C, *Neotermes castaneus,* dorsal, dorso-lateral, lateral, respectively. D, E, F, *Neotermes jouteli.* G, H, I, *Neotermes luykxi.* J, K, L, *Incisitermes snyderi.* M, N, O, *Incisitermes schwarzi.*

mm); mean head length 1.44 mm, mean head width 1.66; eye diameter 0.4–0.5 mm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Neotermes jouteli*

– Mean total body length usually less than 7.5 mm (range 6.50–7.92 mm); mean head length 1.31 mm, mean head width 1.46 mm; eye diameter less than 0.4 mm . . . . . . *Neotermes luykxi*

## SOLDIERS

1. Head phragmotic, with front of face rising sharply at an angle of 50–90° to longitudinal axis; mandibles small relative to size of head capsule (Figs. 2L, 5A–F) . . . . . . . . . . . . . . . . 2

– Head not phragmotic, with front of face sloping gradually at an angle less than 45° to longitudinal axis; mandibles well developed . . . 4

2. One anterior tibial spur on foretibia enlarged, well developed (Fig. 4A) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Calcaritermes nearcticus*

– Tibial spurs on foretibia subequal in length [*Cryptotermes*] . . . . . . . . . . . . . . . . . . . . . . . . . 3

3. Dorsum of head capsule weakly concave; surface of forehead smooth or finely crenulated (Fig. 5B, D, F) . . . . . . . . . *Cryptotermes cavifrons*

– Dorsum of head capsule distinctly concave; surface of forehead deeply convoluted (Fig. 5A, C, E) . . . . . . . . . . . . . . . . *Cryptotermes brevis*

4. Anterior margin of pronotum neither deeply concave nor incised . . . . . . . . . . . . . . . . . . . . 5

– Anterior margin of pronotum deeply concave or incised (Fig. 1H–L) [*Incisitermes*] . . . . . . 10

5. Third antennal article only slightly longer than fourth; hindfemur moderately inflated, with L/W ratio greater than 3.0; head length greater than 3.4 mm; head depth greater than 1.7 mm . . . . . . . . . . . . . . . . . . . . . . . . *Neotermes castaneus*

– Third antennal article subequal to or greater than articles 4 plus 5; hindfemur strongly inflated, with L/W ratio less than 2.6; head length less than 3.4 mm; head depth less than 1.5 mm . . . . . . . . . . . . . . . . . . . . 6

6. Eyes unpigmented . . . . *Kalotermes approximatus*

– Eyes pigmented, purplish, gray, or sooty black . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 7

7. Postmentum length greater than 2.00 mm . 8

– Postmentum length less than 2.00 mm . . . . 9

8. Mean ratio of length of postmentum to its minimum width 7.09; head width 1.9–2.1 mm; width of pronotum usually less than 2.3 mm . . . . . . . . . . . . . . . *Neotermes luykxi* [long-headed]

– Mean ratio of length of postmentum to its minimum width 4.62; head width 2.0–2.5 mm; width of pronotum usually greater than 2.3 mm . . . . . . . . . . *Neotermes jouteli* [long-headed]

9. Head length ca. 2.3 mm (range: 2.0–2.9 mm); head width ca. 1.9 mm (range: 1.7–2.3 mm); head depth ca. 1.3 mm (range: 1.2–1.7 mm); ratio of postmentum length to minimum width usually greater than 4.7 . . . . . . . . . . . . . . . . . . . . . . . . . *Neotermes jouteli* [short-headed]

– Head length less than 2.1 mm (range: 1.8–2.1 mm); head width less than 1.8 mm (range: 1.6–1.8 mm); head depth 1.2 mm (range: 1.0–1.2 mm); ratio of postmentum length to minimum width usually less than 4.5 . . . . . . . . . . . . . . . . . . . . *Neotermes luykxi* [short-headed]

10. Body length less than 6.5 mm; restricted to Florida keys . . . . . . . . . . . . . . *Incisitermes milleri*

– Body length greater than 6.5 mm; range not limited to southern tip of Florida . . . . 11

11. Head length greater than 3.0 mm; postmentum length greater than 2.4 mm . . . . . . . . . . . . . . . . . *Incisitermes schwarzi* [long-headed]

– Head length less than 2.6 mm; postmentum length less than 1.9 mm . . . . . 12

12. Head length greater than 2.3 mm, and head width less than 1.6 mm . . . . . . . . . . . . . . . . . . . . . . *Incisitermes snyderi* [long-headed]

– Head length less than 2.3 mm, and head width either less than 1.5 mm or greater than 1.6 mm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13

13. Head width greater than 1.6 mm; third antennal article usually longer than 4 and 5 combined; head nearly as broad as long; head L/W less than 1.40 (Fig. 1J); antenna usually with 16 articles . *Incisitermes schwarzi* [short-headed]

– Head width less than 1.5 mm; third antennal article no longer than 4 and 5 combined; head longer than broad; head L/W greater than 1.40 (Fig. 1H); antenna usually with fewer than 16 articles . . . . . *Incisitermes snyderi* [short-headed]

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NOTE

# Rapid and Non-Destructive Gender Determination of Nymphal and Adult *Cryptocercus punctulatus* Scudder (Dictyoptera: Cryptocercidae)

The primitive xylophagous cockroach, *Cryptocercus punctulatus* Scudder, is distributed throughout the eastern and northwestern United States. Closely allied to the termites, family units of *C. punctulatus* live within decaying logs (Nelepa. 1984. Behav. Ecol. Sociobiol. 14: 273–279). Because of its unique biology, *C. punctulatus* has become a popular laboratory and field research insect.

The gender of most cockroaches is easily determined by the presence (males) or absence (females) of styles on the sub-genital plate. In addition, the females of many blattid species have divided sub-genital plates. The Cryptocercidae, however, possess expanded seventh tergal and sternal sclerites that completely conceal abdominal segments 8–10, the cerci, and the male's styles (McKittrick. 1964. Cornell Univ. Agric. Exp. Sta. Memoir 389. 197 pp.). Living *C. punctulatus* tightly close their supra- and sub-genital plates concealing the cerci and styles. In addition, living males reportedly have a distinctive odor and females have a dorsal abdominal gland between tergites VI and VII (Seelinger and Seelinger. 1983. Z. Tierpsychol. 61: 315–333). Pinned specimens have either closed genital plates or slightly opened plates with shrunken or hidden styles. In such instances, gender determinations have been based upon dissection. Thus, confirmation of gender by the presence of styles is difficult and time consuming. Herein, I describe a morphological character of the subgenital plate that will allow the rapid and non-destructive determination of gender of *C. punctulatus*.

Examination of living and preserved (n = 43) female *C. punctulatus* revealed apicolateral emarginations of the subgenital plate and a subtruncate apical median prominence (Fig. 1A). These characters were readily visible on nymphs (second through last instar) and adults. There were no emarginations, but a narrowly rounded apical median prominence on this area was present in nymphal and adult male *C. punctulatus* (n = 54) (Fig. 1B). It is possible that subgenital plate emarginations of Cryptocercidae were the precursor to the completely divided plates of the Blattidae. The gender of a few (n = 4; 3.96%) preserved second and third instar *C. punctulatus* nymphs could not be identified by this character. However, these nymphs were light brown and not completely sclerotized. The entire

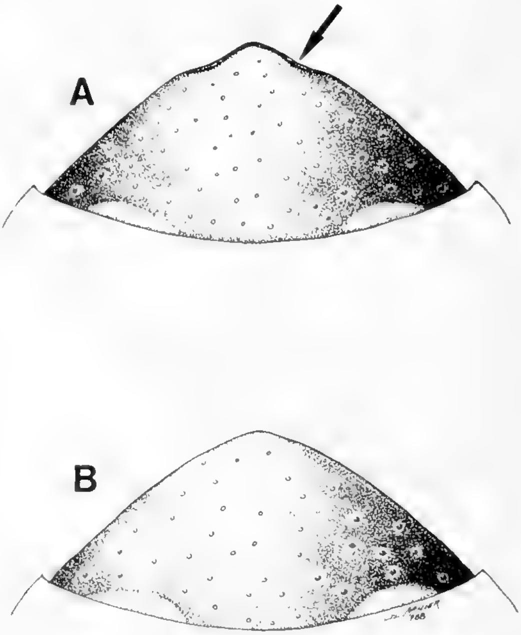

Fig. 1. Subgenital plates of adult female (A) and male (B) *Cryptocercus punctulatus*. Arrow indicates the apicolateral emargination.

subgenital plate had shriveled, making the apical area character ambiguous. With this exception, the presence (female) or absence (male) of an apicolateral emargination of the subgenital plate is a diagnostic character for gender determination in *C. punctulatus.*

I thank W. E. Clark for help with morphological terminology and G. L. Miller for the illustration. This is Alabama Agricultural Experiment Station Journal Series No. 17-881833P.

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# Sex and Deposition of the Holotype of *Bareogonalos canadensis* (Harrington) (Hymenoptera: Trigonalyidae)

Prior to 1900 the yellowjacket parasitoid *Bareogonalos canadensis* (Harrington) was known only from the holotype collected in 1893 at Victoria, British Columbia (Harrington. 1896. Canad. Entomol. 28: 108), and 27 specimens collected on Gabriola Island in 1897 by Taylor (1898. Canad. Entomol. 30: 14–15). The present deposition of 19 of these 28 specimens is known (Table 1). The holotype was reported lost by Townes (1956. Proc. U.S. Nat. Mus. 106: 295–304) but Sarazin (1986. Canad. Entomol. 118: 957–989) claimed that the holotype is in the Canadian National Collection (CNC). From a study of the pre-1900 material, I conclude that the true holotype is in the Zoologisches Museum der Humboldt-Universitaet (Berlin).

Harrington (1896) described the holotype as a male. Taylor (1898) reversed the sexes of his series and Harrington accepted this mistake. Harrington erroneously stated that the holotype was a female, and described the "male" sex using three females (autotypes) (Harrington. 1898. Canad. Entomol. 30: 15–16). Harrington's error, though noted by Schulz (1907a. *In* Wytsman, Genera Insectorum 61: 24 pp.), has been perpetuated by others, including Carlson (1979. 1197–1198. *In* Krombein et al. Catalog of Hymenoptera in America north of Mexico. Vol. I. Smithsonian: Wash., D.C. 1198 pp.) and Sarazin (1986).

The deposition of all four males from Taylor's series is known (Table 1) but at the Zoologisches Museum der Humboldt-Universitaet (Berlin) a fifth male has labels from Taylor's series with a date (24 Oct 1897) on which only females were collected. Schulz [1907b, (1906). Berl. Entomol. Zeit. 51: 303–333] said he received the "typischen Pärchen" (typical pair). This fifth male fits the holotype description; apparently its original labels have been switched with the labels on one of the three autotypes to correspond with Harrington's 1898 statement that the holotype is a female. The holotype currently has labels that read: "Gabriola Isd. B.C., Taylor, 24-10-97 [Taylor's handwriting]/Trigonalys canadensis Harrington, Type ♂ [Harrington's handwriting]/ Zool. Mus., Berlin. [printed label]." The holotype labels, now on the autotype, read: "Victoria V.I. [no date, Harrington's handwriting]/ Trigonalys canadensis Harrington, Type ♀ [Harrington's handwriting]/Zool. Mus., Berlin. [printed label].

Two autotypes at the Canadian National Collection (CNC, Ottawa), with locality and

Table 1. Specimens of *Bareogonalos canadensis* collected from Gabriola Island, B.C., Canada, in October, 1897.

| Date[1] | Number and Sex[1] | Deposition |
|---|---|---|
| 21 Oct | 9 females | 3 at Canadian National Collection (CNC) (1 with yellow paratype label[2])<br>1 H. Townes, Gainesville, Florida |
| 22 Oct | 3 females | |
| | 3 males | 2 at CNC<br>1 at Humboldt |
| 23 Oct | 2 females | 1 at CNC |
| 24 Oct | 4 females | 2 at CNC<br>1 at Humboldt<br>female at Humboldt with Victoria label (no date) actually is autotype from this date[3]<br>(male at Humboldt labeled with this date and locality is holotype collected in 1893[3]) |
| 25 Oct | 2 females | 2 at CNC |
| | 1 male | H. Townes, Gainesville, Florida |
| 26 Oct | 2 females | 1 at CNC<br>1 at Washington State University |
| 27 Oct | 1 female | CNC (With red holotype label[2]) |

[1] This information from Taylor (1898) but corrected for gender.

[2] Type labels at CNC added to autotypes.

[3] Labels of these two specimens switched.

date labels from Taylor's series, have holotype and paratype labels. The 'holotype,' which has a type label in Harrington's handwriting, is dated 27-10-97 but this was apparently interpreted as 27-IX-93 by the person that added the holotype label and again by Sarazin (1986). Harrington (1896) stated the holotype was received by a collector in September 1893, but did not say when it was collected.

Harrington's original "Victoria, V.I." label has been placed on the holotype and the 24-10-97 label of Taylor has been placed on the autotype at the Humboldt museum. The two type specimens in the CNC should be relabeled as autotypes.

I thank J. C. Miller (Oregon State University) and R. D. Akre (Washington State University) for their support; L. Masner (Canadian National Collection) and F. Koch (Humboldt Universitaet, Berlin) for loans of *Bareogonalos canadensis*; and H. Townes (American Entomological Institute) for the information in Schulz (1907b). P. Rossignol, N. Anderson and others at Oregon State University helped clarify this paper and make it more concise.

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## NOTE

# Pedipalpal Anomalies in *Neobisium simoni* (L. Koch) and *N. bernardi* Vachon (Neobisiidae: Pseudoscorpiones: Arachnida)

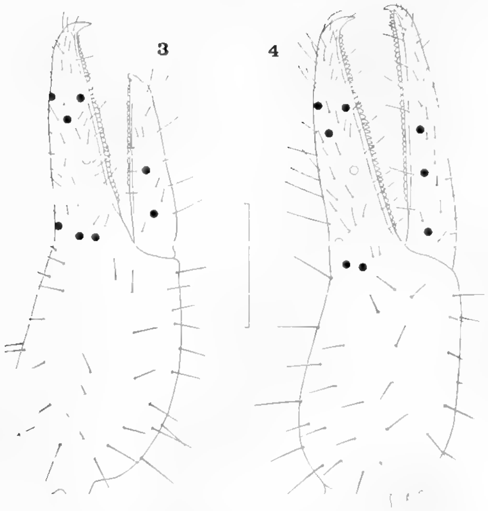
Pseudoscorpions have been found with segmental anomalies involving the sclerites (tergites and sternites) (Ćurčić & Dimitrijević. 1982. Revue Arachnologique. 4, 143–150. 1984. Arch. Sci. Belgrade, 36, 9P–10P. 1985. Revue Arachnologique. 6, 91–98. 1986. Actas X Congr. Int. Aracnol. Jaca/Espana, 1, 17–23, and references cited therein). A curious aberration other than anomaly in sclerite structure has been reported by Vachon (1947. Bull. biol. Fr. Belg. 81, 177–194), who recorded a protonymph of *Chelifer cancroides* (Linnaeus) with the right foreleg fused basally with the pedipalp. In addition, Chamberlin (1949. Amer. Mus. Novit. 1430, 1–57) reported one of the most unusual anomalies yet observed in pseudoscorpions: in the holotype of *Xenochelifer davidi* Chamberlin, the movable finger of the left chela is greatly reduced, being only half the normal length. The fixed finger is apparently normal.

As far as the family Neobisiidae is concerned, pedipalpal anomaly has been recorded in a single female of *N. carpaticum* Beier (Ćurčić. 1980. Bull. Brit. Arachnol. Soc. 5, 9–15). In this pseudoscorpion, the fixed finger of the left pedipalpal chela is greatly reduced, being two-thirds the normal length. Consequently, four distal trichobothria (*ist, est, it* and *et*) are missing and there are also fewer teeth on this finger in comparison to that of the right chela which is normal. The movable finger is apparently normal. In other Neobisiid species, malformations of other appendages (chelicerae, walking legs) occur rarely, as was already observed by Ćurčić (1980). The aim of this note is to express quantitatively and qualitatively the phenomena of pedipalpal teratology in the species studied in order to assess the pathomorphological traits of such aberrations.

In a collection of pseudoscorpions made by one of us (RND) at Passarole, near Moulis (Ariège), France, during July 1987, one female of *Neobisium simoni* (L. Koch) and one tritonymph of *N. bernardi* Vachon with abnormal pedipalpal chelae were found. These were obtained by sifting leaf-litter and humus in a mixed oak forest. In the specimens studied, only the pedipalpal chelae were anomalous, the other appendages and abdominal sclerites were normal.

*NEOBISIUM SIMONI:* Female (Figs. 1 & 2). The fixed finger of the right chela of the pedipalp is reduced, being only half the normal length. Consequently, instead of four distal trichobothria, a single tactile seta is present (Fig. 1). Its relative position is more basal than in any of the distal trichobothria:

Figs. 1–2. *Neobisium simoni* (L. Koch). Scale line = 0.5 mm. (1) Right chela of the pedipalps, aberrant female, (2) Right chela of the pedipalps, normal female.



Figs. 3–4. *Neobisium bernardi* Vachon. Scale line = 0.5 mm. (3) Right chela of the pedipalps, aberrant tritonymph, (4) Right chela of the pedipalps, normal tritonymph.

therefore, its proper identification is not possible. In addition, the deficient finger carries 37 teeth only, whereas the normal complement is 58–64 teeth (Fig. 2). The movable finger is apparently normal and carries 60 teeth, which falls within the normal range for the movable finger (54–60 teeth) in females of this species.

*NEOBISIUM BERNARDI:* Tritonymph (Figs. 3, 4). The movable finger of the right pedipalpal chela is reduced and attains two-thirds the normal length (Fig. 3). In addition, this finger carries two instead of three trichobothria (seta *t* is missing). The fixed finger is normal. The anomalous finger has 25 teeth and the normal complement is 32–38 teeth. They appear much smaller and more close-set than in normal specimens. The fixed finger carries 38 teeth (normal range is 35–40 teeth). In both *N. simoni* and *N. bernardi* studied left pedipalpal chelae are normal.

The pedipalpal anomalies in different species of *Neobisium* Chamberlin from the family Neobisiidae have been found to date in the adult (female) and tritonymph stages (*N. carpaticum, N. simoni, N. bernardi*). No deficiencies have been noted in the deutonymph or protonymph stages.

It appears probable that the origin of the pedipalpal anomalies analyzed should be sought in some irregularity of the ontogenic (? postembryonic) process.

We are grateful to Dr. Christian Juberthie, Director of the Laboratoire souterrain in Moulis, for his collaboration and permission to collect pseudoscorpions in the vicinity of Moulis.

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## NOTE

# Ticks of the Subgenus *Ixodiopsis*: First Report of *Ixodes woodi* from Man and Remarks on *Ixodes holdenriedi*, a New Junior Synonym of *Ixodes ochotonae* (Acari: Ixodidae)

Recently, this laboratory received a partially engorged nymphal *Ixodes* tick that had been removed from the neck of a child (age and sex not stated) on 5 June 1967 at Francis E. Warren Air Force Base, Laramie Co., Wyoming. No previous effort had been made to determine the specific identity of this specimen, probably because the only available key to the *Ixodes* nymphs of North America, that of Cooley and Kohls (1945, Natl. Inst. Health Bull. 184: 1–246), is out of date (nymphs were known for only 26 of the 41 species treated by Cooley and Kohls; since then, several taxa have been synonymized and 6 new species have been described). Careful comparison with material in the U.S. National (formerly Rocky Mountain Laboratories) Tick Collection has shown that the Wyoming specimen is *Ixodes woodi* Bishopp, a member of the morphologically close-knit subgenus *Ixodiopsis* Filippova, which comprises 7 species, all chiefly parasites of small rodents and insectivores (Robbins and Keirans 1987, J. Med. Entomol. 24: 310–314). This is the first known instance of human parasitization by *I. woodi.*

In North America, the subgenus *Ixodiopsis* is often referred to as the "*Ixodes angustus* group," after *Ixodes angustus* Neumann, a widespread parasite of cricetid rodents. Other Nearctic members of the *I. angustus* group include (besides *I. woodi*) *Ixodes eastoni* Keirans and Clifford, to date known only from southwestern South Dakota and the border area of northeastern Wyoming, where it parasitizes cricetine and microtine rodents; *Ixodes ochotonae* Gregson, a parasite of ochotonid lagomorphs and, to a lesser extent, cricetines in the montane West; and *Ixodes soricis* Gregson, a characteristic tick of western soricid insectivores. Another taxon that would appear to fit the definition of subgenus *Ixodiopsis* is *Ixodes holdenriedi* Cooley, which is known only from the holotype and paratype, both females taken on the pocket gopher *Thomomys bottae* (Eydoux and Gervais), Sonoma Co., California, 25 March 1945. It seems remarkable that during more than 40 years no further specimens have come to hand in an area that has been particularly well worked by acarologists and public health personnel. Examination of the original description and of the type material (now in poor condition) indicates that *I. holdenriedi* is conspecific with, and therefore a junior synonym of, *I. ochotonae.*

Though Spencer (1963, Proc. Entomol. Soc. Brit. Columbia 60: 40) published a record of *I. soricis* from a girl, all other reports of *Ixodiopsis* ticks from man pertain to *Ixodes angustus.* As early as 1937, Chamberlin (Stn. Bull. Oregon Agric. Exp. Stn. 349: 1–34) noted that *I. angustus* will definitely feed on man, but he did not cite specific examples. Later, Cooley (1946, J. Parasitol. 32: 210) described 3 cases of human parasitization by *I. angustus* in the Pacific Northwest, Gregson (1956, Publ. Dep. Agric. Canada 930: 1–92) noted 2 cases from southwestern British Columbia, and Spencer (op. cit.) added 3 more records from that Province. In addition to these published records, there are 4 specimens in the Fred C. Bishopp Collection (now merged with the National Tick Collection) that were removed from humans: 1 partially engorged ♀ from the scalp of a boy, Sandy River, Multnomah Co., Oregon, 7 August 1934 (RML 118942); 2 partially engorged ♀♀ from the arm of a 14-year-old girl, Forest Grove, Washington Co., Oregon, 8 August 1932 (RML 118959); and 1 partially engorged ♀ "taken from the shoulder of a man who complained of rheumatic pains .... Tick was firmly attached. Rheumatic symptoms soon subsided after removal of tick," Vancouver, Clark Co., Washington, 11 July 1938 (RML 118964). There are also 4 unpublished records in the National Tick Collection itself: 1 engorged ♀ from a child, Kirkland, King Co., Washington, August 1947 (RML 24023); 1 engorged ♀ from a young boy, Washington [State], 20 July 1956 (RML 33925); 1 partially engorged ♀ from the head of a young girl, Seattle, King Co., Washington, ca. 2 August 1977 (attachment site became inflamed on 12 August) (RML 105346); and 1 engorged ♀ from an otherwise undefined human host, Juneau, Greater Juneau Borough, Alaska, 1 August 1953 (RML 118623).

The nymph of *I. woodi* reported herein (RML 118594) may be described as follows (measurements in millimeters): Length of body from scapular apices to posterior margin 2.157, greatest width 1.395; length of capitulum from palpal apices to cornua apices 0.297, width at level of cornua 0.261; palpi 0.245 long, 0.091 wide, segment I ventrally without an anterior spur but with a prominent posterior spur that projects laterally; hypostome broken; scutum 0.598 long, 0.581 wide; left tarsus I missing, right 0.287 long, 0.121 wide.

Thanks to Jerome Goddard, U.S. Air Force School of Aerospace Medicine, Brooks Air Force Base, San Antonio, Texas, for sending this most significant specimen.

Richard G. Robbins, *Department of Health and Human Services, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, % Department of Entomology, Museum Support Center, Smithsonian Institution, Washington, D.C. 20560.*

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# BOOK REVIEW

*Lepidoptera Anatomy.* By John L. Eaton. Wiley-Interscience (John Wiley & Sons), New York, 1988, 257 p. $49.95.

The need for a comprehensive, revised text on comparative anatomy of Lepidoptera has long been realized. Several important morphological studies, particularly by German and Russian authors, appeared in the early decades of this century. Most of these classics are no longer readily available, or are unavailable in English, and recent studies are so specific in the anatomical areas discussed as to be of limited use as general references. Unfortunately, the recent volume entitled *Lepidoptera Anatomy* by John Eaton fails this need in several respects. Most importantly, prospective purchasers of this rather small but expensive volume ($49.95) should be informed that Eaton's book is not a review of general lepidopteran anatomy as its title implies. Instead it is primarily a description of all stages of the sphingid, *Manduca sexta* (L.), which has been the primary and almost exclusive focus of Eaton's research over the years. As a result, much of the text reads like a laboratory guide for the study of the tobacco hornworm moth, with little reference to other species. Only in few chapters and largely because of necessity (e.g. in the chapter on sound production), are other Lepidoptera discussed.

In his preface, Eaton states that he has chosen *Manduca sexta* as a model for the Lepidoptera. The "archetype" or "model" approach for studies involving such vast subjects certainly represents a logical and often necessary method of treatment. Criticism arises in the choice of the models and, especially in this case, how many models should be included to provide an adequate representation for the Lepidoptera. Selection of one of the most specialized members (a sphingid) of the order is not likely to result in a representative example. At a minimum, it probably would have been necessary to discuss examples from the Micropterigidae, Incurvarioidea, Tineidae, Pyralidae, Noctuidae, and probably Papilionidae in order to present a meaningful review of the anatomical diversity within the order.

The text is divided into 11 chapters, which vary considerably in scope and quality. Not surprisingly, those chapters which had largely been treated previously by Eaton in the Annals of the Entomological Society of America (e.g. the larval and adult musculature, nervous and endocrine systems) are the best researched and most informative. The remaining chapters, dealing mostly with external morphology, are clearly written but brief and are generally inferior to references currently available. Literature references are included at the end of each chapter. These also vary in coverage according to chapter and frequently do not provide an adequate representation of the best references. The most conspicuous omissions in the text are the lack of references to larval chaetotaxy and scale morphology. Considering the importance of these structures for the order, their absence constitutes a major oversight.

The subject matter is amply supported by numerous, well labelled, line drawings. In addition to a complete listing of all label anagrams in a terminal appendix, some of the more complex illustrations (e.g. fig. 4–25) also are provided with anagram legends which reduce page flipping appreciably. The quality of illustrations, like the text, varies among chapters, with those previously published elsewhere generally being superior to those prepared for the book. Several drawings appear oversized and crudely executed with a conspicuous lack of certain details or accuracy (e.g. larval chaetotaxy). One rather surprising omission noted for a modern anatomical text is the absence of electron micrographs, particularly SEM photos. Details shown by such photographs are sorely needed in support of the text dealing with sensory structures and trophic organs. Although no SEM photographs of eggs are shown, the drawings for this brief chapter reportedly were based on SEM studies.

In summary, the main criticism of this book is its misleading title and all that it implies. I would recommend the text as a reference primarily for beginning students of Lepidoptera anatomy and especially for those interested in internal anatomy. For those primarily concerned with external anatomy, they would be best advised to search elsewhere for one of several superior references currently available.

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*Asa Fitch and the Emergence of American Entomology.* By Jeffrey K. Barnes. Bull. No. 461, New York State Museum, Albany, New York, 1988, viii and 120 pp. $12.50 + $1.00 postage and handling, from New York State Museum Publications, 3140 Cultural Education Center, Albany, NY 12230.

With a marvelous grasp of the history of the mid-nineteenth century in New York, Barnes has written a fine appreciation of Asa Fitch and the beginnings of the science of entomology in North America. Fitch's life is sketched in a series of nine chapters interwoven with three more that set his life within the larger context of the times.

The early part of the nineteenth century in New York when Fitch came of age was optimistic and progressive. Barnes places Fitch in a period of expanding economy, growth of educational and scientific establishments, great migration, cheaper travel, religious ferment, and new agricultural developments. Because of more extensive farming and the need to grow crops more efficiently, insect damage became more noticeable. Albany, the capital of the richest state, was a center of scientific activity (foreign scientists arriving in Boston asked directions to Albany), due largely to its position at the confluence of two rivers and at the beginning of the new Erie canal.

Little was known about American insects before 1845. Although Thomas Say had already described about 1500 species, those insects, with a few exceptions, were not crop-related. The study of insects lagged behind other natural history studies and people had strange notions concerning insect control. But it was apparent to many that insects were becoming more important to the development of agriculture and that little was known about how to fight them effectively. Fitch, a product of his times, a man of social purpose deeply interested in science, was well-placed by his education, interests, and integrity to be influential in the growth of the new field of entomology.

Fitch was born in 1809, the same year as Abraham Lincoln. We learn of his early years on a farm, his education in the natural sciences, travels, medical education. He entered the practice of medicine, but lacked respect for the profession and eventually quit. While still young, Fitch returned to life as a farmer. Because he was well-to-do he was able to devote much of his time and energy to insect study. His first papers, written as early as 1845 while still an amateur, were excellent treatments of insects injurious to plants. During 1846–8 he was paid to make a collection of insects for the State Cabinet of Natural History, a collection that included plant damage and which was eventually placed in the State Museum. Largely due to his demonstrated knowledge and with a little help from well-placed friends, he won in 1854 the post of State Agricultural Society Entomologist. Fitch continued in that capacity for 19 years, during which he wrote 14 annual reports and many smaller papers.

Fitch was also greatly committed to education. He always had in mind that science should "relate to the common purposes of life." Previous scientific reports in the state had been criticized for being unintelligible to ordinary citizens and of little practical value. But Fitch's reports can still stand as models because they were useful to both scientists and farmers and simply written. Fitch carefully observed the life cycles of many insects for the first time. As he told the young Henry Comstock, then looking for guidance, the best way to begin the study of insects is to observe their behavior. Fitch's recommendations for the control of insects, including critical growing times, selection for early or late plant varieties, and biological control (he was the first to suggest getting parasites from abroad to fight immigrant pests), were highly influential. His reports continued to be in demand decades after they were written. Even in Europe they were popular because of their practical application. C. V. Riley rightly called Fitch the father of economic entomology in North America.

The book has a large page (10¾″ by 8½″), two column format, is well illustrated with copies of photographs and prints and with some of Barnes' own photos of historic places, and is printed on excellent stock. Each of the 12 regular chapters has its own reference notes immediately following. Two appendices follow. The first is a list of Fitch's entomological publications. The second appendix is an appreciation of Fitch's taxonomic work, with a discussion of his collections and a catalog of his taxonomic names and type specimens. The list of his extant types in 3 classes, 15 orders, and 107 families is hierarchically arranged, complete, most valuable, and reflects a great amount of careful museum work by Barnes. In this section I noticed a typographical error, possibly done purposely, in the same way that an otherwise perfect, handmade oriental rug has a tiny flaw woven into it to ward off the evil eye.

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PROC. ENTOMOL. SOC. WASH.
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# Book Review

*The Mayflies of Florida,* Revised Edition. By Lewis Berner and Manuel L. Pescador. University Presses of Florida. 1988, xvi + 415 pp. ISBN 0-8130-0845-X. $35.00/hard, from 15 NW St., Gainesville, FL 32603.

The original edition of *The Mayflies of Florida* by Lewis Berner was published in 1950, and the numerous detailed observations it contained were an invaluable source of data on the natural history of Ephemeroptera. It has been out-of-print for a number of years, but fortunately Berner, with the aid of his new coauthor Pescador, has provided an updated edition. The format remains basically the same, but new data and recent references have been added and discussions have been more compartmentalized. A total of 71 species are treated in this edition, a significant increase of 23 since 1950. Much added data were undoubtedly contributed by the aquatic entomologists at Florida A&M University, particularly with regard to studies in the Florida panhandle region. There are now 28 plates of very good habitus drawings (not numbered as figures), 174 numbered figures, and 27 distribution maps, an impressive increase over the 24, 88, and 19, respectively, of the earlier edition.

Chapters include an introduction that contains a generalized account of the biology of the various life stages, morphological adaptations of larvae, higher classification, and taxonomic characters. This is a clear and concise discussion that non-specialists will appreciate; however, it would have been more useful if figure citations had been liberally cited to accompany the adaptation and character discussions. A chapter comparing the Florida fauna with more northern ones emphasizes the relative non-seasonality of many Florida populations. An excellent chapter entitled Zoogeography deals with distributions in the context of the geological history of the peninsula along with descriptions of the many available aquatic habitats. This is valuable information for those interested in any of the freshwater biota of Florida. A species key to the adults (mainly males) and larvae makes up the next chapter. It reflects the present state of knowledge about generic and specific differences and is well illustrated. The key is followed by a synoptic list of species and finally the individual species treatments.

The taxonomy is essentially up-to-date, the most notable exception being in the family Baetidae, whose genera are undergoing considerable revision. The validity of a few of the species that the authors recognize is in some doubt. Of the 71 species treated, 6 are apparently endemic to Florida. The doubtful species are among these endemics, some of which may arguably be ecophenotypic variants. The great strength of the book remains the wealth of original observational data that can be gleaned from the topics treated under each species. These include taxonomy (diagnostic but not descriptive); distribution; ecology (mainly a discussion of specific habitats); seasonality and life history (often including emergence and reproductive behavior); and behavior (mainly larval orientation and feeding). Searching for information about certain phenomena without knowing to which species it may pertain can be a real problem with this type of format. In this book, however, there is, happily, a very complete index to subject matter. Citations available since 1950 are quite complete, with very few pertinent behavioral and ecological publications missed.

For those workers who found the original edition of this book useful, this revision will better serve them. For the newer generation of researchers and students who have not been able to obtain the book previously, the new edition is most worthy of their attention. And for entomologists, naturalists, and aquatic biologists in the Southeast, the book should definitely be considered for their reference libraries.

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## OBITUARY

Frederick William Poos, Jr.
1891–1987

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Frederick William Poos, Jr., a member of the Entomological Society of Washington since 1923, President of the Society in 1945 and Honorary Member since 1966, died from surgical complications on June 28, 1987. Dr. Poos lived in northern Virginia. His wife died in 1974. He is survived by two sons: Frederick William Poos III, Long Island, New York and George Ireland Poos, Fort Washington, Pennsylvania.

Dr. Poos was born in Potter, Kansas on November 12, 1891, the son of Frederick W. and Dena (Steinhage) Poos. He grew up in Kansas and attended the University of Kansas where he received his A.B. in 1915 and A.M. in 1916. He worked for the Bureau of Plant Industry in Florida from 1916 to 1917 and from 1917 to 1922 for the Bureau of Entomology, USDA, in Charlottesville, Virginia. During this time he co-authored a number of papers on stem-boring insects of wheat and corn. He married Edna M. Ireland in 1919. In 1922 he moved to Sandusky, Ohio as assistant entomologist in charge of the European Corn Borer Station. At this time he worked on his Ph.D., which he received from Ohio State University in 1926. His Ph.D. thesis treated the biology of the European corn borer and two closely related species in Ohio. From 1926 to 1928 he worked at the Virginia Truck Experiment Station in Norfolk, Virginia on insects attacking spinach, potatoes, narcissus and roses. In 1928 he returned to work for the USDA, Bureau of Entomology and Plant Quarantine at the experimental farm in Arlington, Virginia.

Prior to 1928 Dr. Poos had made important contributions to the field of economic entomology. His early work was on the biology and control of the European corn borer, larger corn stalk borer, wheat strawworm and wheat jointworm. His recommendations for cultural and biological control still have merit. He also did noteworthy work on the life history and control measures for the Hawaiian beet webworm on spinach. He developed an effective spray calendar for use in a five state area. Upon his return to the USDA experimental farm in 1928 he began an outstanding career involving various insect pests, especially those of potatoes and peanuts. He discovered the insect vector, the corn flea beetle, of Stewart's disease of corn. This important breakthrough led to important control measures for the vector and the disease. Dr. Poos, in collaboration with Hurd-Karren was the first in the United States to discover the systemic action of insecticides in plants. Dr. Poos also was well known for his work on leafhoppers and in particular the potato leafhopper. He was the first to discover that this insect migrates from southern to northern states each year. He discovered a number of practical control measures for pests of peanuts. He identified the cause of a disease of peanuts, that was uncertain for years, was actually the tobacco thrips. Another of his fields of research was insects attacking soybeans.

When, in 1941, the property on which the experimental farm was located was needed for construction of a large military headquarters, later known as the "Pentagon," Dr. Poos moved to Beltsville, Maryland to continue his research. He worked at Beltsville until his retirement in 1957. His research at Beltsville included studies on injurious insects attacking legume and grass crops. In addition to his work on the use of new insecticides to control pests, he also was responsible for studies on the effect of insecticides on dairy cows and their milk.

In 1954 he received the Superior Service Award from the USDA and in 1963 he received a citation of merit from the Entomological Society of America. In 1982 Dr. Poos received international acclaim in a very unusual manner. The well-known piece of entomological equipment called the "aspirator" is known in England as a "pooter." The origin of the term "pooter" came to light in the October 1982 issue of *Antenna,* a British Entomology Journal, where it was disclosed that the term is derived from the name "Poos." Dr. Poos, the first to use the aspirator in collecting leafhoppers, described it in a 1929 article. British entomologists coined the term "pooter" to indicate the device used by Dr. Poos.

Dr. Poos had been a member of the Presbyterian Church of the Pilgrims since 1929, where he had served as an elder. He was a member of numerous societies including the American Association for the Advancement of Science, Entomological Society of America (honorary member), American Association of Economic Entomologists, Biological Society of Washington, Kansas Entomological Society, Kansas, Ohio, and Washington (DC) academies of science, Sigma Xi, and Cosmos Club in Washington, DC. He also served as editor for the Journal of Economic Entomology. He was always an active person both professionally and in civic activities. He was active and alert even as he went into surgery on June 25, 1987. Many entomologists in the Washington area knew him well and often visited with him.

His death marks the loss of one of the great contributors to entomology in the service of American farmers and consumers.

Thomas E. Wallenmaier, *Room 608, Federal Building, Hyattsville, Maryland 20782.*

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# OBITUARY

Donald Joyce Borror
1907–1988

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With extreme sadness I learned of the death of Dr. Donald J. Borror, Professor Emeritus of Entomology at The Ohio State University, at age 80, on April 28, 1988. He was born on August 24, 1907 in Shepard, Franklin Co., Ohio, as the second son of the Reverend Charles H. Borror. He attended Otterbein College and received his B.S. degree in 1928, the M.S. degree in Entomology in 1930 at The Ohio State University, and his Ph.D. degree in Entomology at the Ohio State University in 1935; for the latter two degrees he worked on the systematics of dragonflies. He was a member of the faculty of the Department of Zoology and Entomology at The Ohio State University until his retirement in 1978, except for duty with the Navy during World War II. At The Ohio State University he taught general and systematic entomology, insect morphology, ornithology, and bioacoustics. He was senior author of a textbook "An Introduction to the study of Insects" and of "A Field Guide to the Insects." He has produced several records and cassettes of bird songs, and founded the Ohio State Borror Laboratory of Bioacoustics.

Dr. Borror was a Fellow of the Entomological Society of America, Chairman of the teaching section (1955), Assistant Managing Editor of the Entomological Society of America Annals (1943–44), and received the North Central Branch Award of Merit in 1974. He was a Fellow of the American Association for the Advancement of Science and of the Ohio Academy of Science, a member of the Society of Systematic Zoology, Sigma Xi, the American, Wilson and Cooper Ornithological Societies, and the National Audubon Society

My association with Dr. Borror began when I entered graduate school at The Ohio

State University in 1957. New students in Entomology were told by older students what to expect of various instructors and their classes; these sessions invariably concentrated on Dr. Borror and his classes and were a great aid in preparation for what lay ahead. The demands placed on the student by Dr. Borror were greater than those imposed by any other college instructor that I have ever had. He expected his students to work as hard and efficiently as he did. It is true that not all of Dr. Borror's students relished the experience, but for me it was exactly what I was there for, and I reveled in it.

In my first meeting with Dr. Borror, I claimed a good knowledge of beetles. A look of scepticism followed, whereupon he immediately arose, walked over to a shelf, pulled out a box of assorted beetles, pointed to one, and said, "What family is this one?" One by one, I correctly named the family to which each belonged. Dr. Borror was one to base a conclusion on sound evidence only, not on hearsay.

Those who assisted in preparation of specimens for his morphology classes were always amazed at his ability to recall details of the morphology collection. Typical preclass instructions to the assistant by Dr. Borror would go as follows: "Now we have just four specimens of this family, and I collected two of them in Maine, I want you to put out two for the class to examine." The assistant would invariably find that Dr. Borror's memory was accurate. This may not seem impressive to a non-entomologist, but there are nearly 580 families of insects in North America, and over 90% of them were represented in the morphology collection.

One graduate student enjoyed putting the teaching style of the instructors in graph form. A dot at each end of a piece of paper represented the subject matter to be taught. The line drawn from one side of the paper to the other represented the various paths taken by the instructors during the lecture. The line of an instructor who enjoyed an initial chat with students started to one side of the dot, then approached and joined the mid region to end up on the final dot. It was amusing to see this student plot various manners of lines (meandering, jagged, etc.), then say, who is this? We would often correctly respond, "Oh, that's Dr. - - - -." The line for Dr. Borror's style was immediately guessed by one and all: a solid, perfectly straight line from one dot to the other.

A graduate department is only as good as its instructors, and to me Dr. Borror made the systematic and morphology section of Entomology at The Ohio State University truly outstanding. I do not see how better training could have been given than that which he provided. He was by far the greatest academic influence in my life.

I was very fortunate to have been a graduate student at The Ohio State University when Dr. Borror was approached by a representative of Houghton Mifflin and asked to do an Insect Guide for the Peterson Field Guide Series. He was not one to turn down a challenge, but needed an artist to do the drawings that he could not handle. It is difficult to express the extreme feeling of satisfaction and joy experienced when Donald Borror asked me to work with him on the insect guide. Work on the insect guide got started in 1964; the work was completed in 1967. Field guide authors must invariably do the work in the midst of other activities, and it typically takes many years to produce a guide. It is rare that one is produced as rapidly as the 3½ years that it took Donald Borror and I to do this one.

A reviewer of the insect guide predicted that the book would sell more copies than any other book on insects ever written; that reviewer's prediction has doubtless been borne out. For the period of 1970 to June 15, 1988, the insect guide has sold 412,790 copies, a level of sales never expected by anyone connected with the project.

The association with Donald Borror gives me, I feel, a full understanding of the intellectual capabilities of true genius. I was not alone in being much impressed with him. In a letter of October 12, 1964, Roger Peterson remarked on his construction plans for the insect guide as follows: "What a first-rate worker you are! A real pro! I have looked over your construction plans for the insect field guide with great interest, and they are going to work out just fine." Dr. Borror's handling of the work on the insect guide was truly masterful. Helen Phillips of Houghton Mifflin referred to him as the most proficient field guide author with whom she had ever worked, and noted that she had found only three typographical errors in more than 1500 pages of typing that he did for the insect guide.

I enjoy reflecting on encounters with Donald Borror in the halls of the Botany and Zoology building at The Ohio State University. He is striding along at near top speed, gives you a warm grin, says "Howdy," then continues unslowed to the task at hand. The image is of a strong, determined, and quiet (even shy) individual, and a true leader who set a high standard of excellence for colleagues and students alike in all work he did.

To have been a student of, and worked with Donald Borror was a grand intellectual experience. It was, for me, the best of all possible times. My association with him was one that I will cherish as much as any that I have ever had. I say with great pride that I had the privilege and honor of having known and worked with a truly great man. He will be missed by all who knew him.

Richard E. White, *Systematic Entomology Laboratory, Plant Sciences, Agr. Res. Serv., USDA, % U.S. National Museum of Nat. Hist., Washington, D.C. 20560.*

Photo courtesy of Frank W. Mead, Fla. Dept. Agr. and Consumer Serv., Div. Plant Ind., Gainesville.

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## ENTOMOLOGICAL SOCIETY OF WASHINGTON
## NEW MEMBERS FOR 1988

Masaki Abe
Alfred P. Arthur
Art Borkent
David Carmean
Christopher H. Dietrich
Robert M. Eisenberg
John D. Glaser
Harold J. Harlan
Lawrence E. Hurd
Edward A. Lisowski
Hans K. Loechelt
Robin Trevor Lubbert
Terry D. Miller
Stephen R. Moulton II
Mark A. Muegge
Allen L. Norrbom
Roy A. Norton
Robin J. Rathman
Eric Wellington Riddick
Thomas E. Rogers
Sara S. Rosenthal
John D. Sedlacek
Gary J. Steck
Brian M. Wiegmann
Richard C. Wilkerson

Total new members for 1988: 25

Total membership as of 1 December 1988: 547

Submitted by Geoffrey B. White, *Membership Chairman,* 944th Regular Meeting, 1 December 1988.

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91(2), 1989, pp. 307–310

# SOCIETY MEETINGS

## 941st Regular Meeting—May 5, 1988

The 941st Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8 p.m. on 5 May 1988. Eighteen members and three guests were present. Minutes of the previous meeting were read and approved with one alteration. No old business was transacted, nor were there any applicants for membership.

F. C. Thompson distributed handouts describing the location and program of this year's annual banquet, which will be jointly sponsored by our own Society, the Pest Science Society of Washington, and the Maryland Entomological Society. This year the Master of Ceremonies will be Ronald J. McGinley, Chairman, Department of Entomology, Smithsonian Institution.

R. G. Robbins distributed lists of Chinese papers on ticks and mosquitoes that have been translated by his wife Fu-meei. Among these translations are several major biogeographic surveys, such as Teng Kuo-fan's "Ticks of Tibet" and Ma Su-fang's "Studies on the *Anopheles* (*A.*) *sinensis* group of mosquitoes in China." Persons interested in obtaining either lists or translations should contact the Recording Secretary at the address on the inside front cover of this issue or call (301) 423-5693 during regular business hours, E.S.T.

The speaker for the evening was Lance A. Durden, Research Collaborator, Department of Entomology, Smithsonian Institution, whose talk was entitled "Project Wallace: Bioendemism, Mammal Ectoparasites and Some Other Insects in Sulawesi." Dr. Durden illustrated his presentation with many beautiful slides as well as an exhibit of insects that he had collected in northern Sulawesi. Don R. Davis of the Smithsonian's Department of Entomology was delighted to discover in this collection a single specimen of the rare and unusual tineid moth *Ischnuridea virginella* Sauber, on which he has recently published. Until Davis collected four specimens on Mindanao in 1965, this species had only been known from the damaged female type, also collected on Mindanao in 1882. Like the Durden example, all subsequent specimens have been taken on Sulawesi by Project Wallace staff. Though a member of the clothes moth family Tineidae, *Ischnuridea* is atypical in possessing an extremely long, piercing ovipositor that is thought to be an adaptation for depositing eggs into the pithy stems of living *Musa* (i.e. bananas, etc.). Dr. Durden has graciously donated his specimen to the Smithsonian Institution.

Dr. Davis also announced that he is organizing an entomological delegation to the People's Republic of China, which will depart on or about 9 September of this year. Participants will tour most major entomological collections in mainland China as well as the panda research station. About half of each day will be spent visiting points of natural or historical interest, but there may also be opportunities for field work. All entomologists, regardless of affiliation, will be warmly welcomed and each is invited, at his option, to deliver a short talk on his area of expertise. Though systematic entomology will be emphasized, Don is also interested in hearing from anyone with experience in biocontrol. The cost per person is $3550 round trip from San Francisco, but up to 80% of this amount may be tax-deductible.

Mignon Davis complimented Jil Swearingen, Warren Steiner, and Doug Sutherland for bringing such a tempting array of refreshments to our final meeting before the summer recess. In happy anticipation of this repast, the meeting was adjourned at 9:10 p.m.

Richard G. Robbins, *Recording Secretary*

## 942nd Regular Meeting—October 6, 1988

The 942nd Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8 p.m. on 6 October 1988. Twenty members and 14 guests were present. Minutes of the May meeting were read and approved.

D. H. Messersmith announced that he has been appointed to chair a committee to study the feasibility of affording affiliate status to other entomological organizations for the purpose of publishing summaries of their minutes or brief notices of their activities in our *Proceedings*. M. S. Collins strongly endorsed this idea. However, T. J. Spilman reminded the membership that he had voiced a similar suggestion in the early 1960's but that there had been no follow-through. Dr. Messersmith would welcome additional comments on such intersocietal cooperation.

Membership Chairman G. B. White read the names of the following applicants for membership: Masaki Abe, Systematic Entomology Laboratory, USDA, Smithsonian Institution; David Carmean, Department of Entomology, Oregon State University, Corvallis; Harold J. Harlan, Crownsville, Maryland; Robin Trevor Lubbert, Beltsville, Maryland; Mark A. Muegge, Department of Entomology and Plant Pathology, University of Tennessee, Knoxville; Eric Wellington Riddick, Washington, D.C.; Thomas E. Rogers, Kenner, Louisiana; Sara S. Rosenthal, Bozeman, Montana; Brian M. Wiegmann, Department of Entomology, University of Maryland, College Park; and Richard C. Wilkerson, Walter Reed Biosystematics Unit, Smithsonian Institution.

W. E. Bickley asked whether nominations had been received for a third Honorary Member. President Wood replied that nominations would be considered at a forthcoming meeting of the Executive Committee. The President then asked to borrow any entomological cartoons *sensu* "The Far Side" that members or their friends would like to see exhibited at this year's National Conference of the Entomological Society of America, to be held in Louisville, Kentucky. Original drawings should be sent to Dr. Wood no later than mid-October.

J. H. Fales displayed and discussed the lepidopterological fruits of his summers afield: striking aberrations of several mid-Atlantic butterfly species; and a series of the late season dark form of *Junonia coenia* Hübner, which has reddish hind wings ventrally. Fales also exhibited a specimen of *Euphyes ruricola metacomet* (Harris), taken for the first time in Rock Creek Park, Washington, D.C., on 10 August of this year. On 19 September, Fales was at Plum Point, Calvert County, Maryland, where he collected a single *Danaus plexippus* (Linnaeus) marked with white paint along the ventral external margins of the left fore- and hind wings. He has added this specimen to his personal collection of marked butterflies and other insects, which was also shown to the membership.

The speaker for the evening was Candy Feller, Research Collaborator, Department of Entomology, Smithsonian Institution, who is well known as a former free-lance artist at the National Museum of Natural History and is now a graduate student at Georgetown University. Her talk, entitled "Insects on Mangrove Cays: Preliminary Studies in Belize," revealed the remarkable diversity of insects and other creatures associated with these polyphyletic trees and shrubs that fringe tropical tidal shores.

T. J. Spilman announced the recent death of Jack E. Lipes (18 February 1924–17 September 1988), USDA–APHIS, a much admired member of this Society and our President in 1981.

Visitors were introduced and the meeting was adjourned at 9:25 p.m. Refreshments followed.

Richard G. Robbins, *Recording Secretary,* Geoffrey B. White, *Membership Chairman*

## 943rd Regular Meeting—November 3, 1988

The 943rd Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8:10 p.m. on 3 November 1988. Eighteen members and 6 guests were present. Minutes of the October meeting were read and approved.

Mignon Davis circulated a sign-up sheet for members who would like to volunteer to bring refreshments to our meetings.

President Wood announced that the Society had twice received the name of Alan Stone for Honorary Membership and that the Executive Committee had unanimously agreed to nominate Dr. Stone in recognition of his distinguished career in mosquito systematics. Dr. Wood next placed this nomination before the ESW audience, where it was approved by acclamation.

Membership Chairman G. B. White read the name of the following applicant for membership: Allen L. Norrbom, Systematic Entomology Laboratory, USDA, Smithsonian Institution.

President Wood, assisted by D. M. Anderson, unveiled a provisional slate of officers for 1989: President-Elect, vacant; Treasurer, Norman E. Woodley; Editor, Hiram G. Larew; Associate Editor, vacant; Recording Secretary, Richard G. Robbins; Corresponding Secretary, John M. Kingsolver; Program Chairman, Warren E. Steiner, Jr.; Membership Chairman, Geoffrey B. White; Custodian, Anne M. Wieber. Dr. Wood then announced the immediate formation of a Nominating Committee to fill the vacancies in this list.

At the request of President Wood, R. G. Robbins noted this Society's heartfelt concern for the health of Robert Traub, the world's foremost authority on Siphonaptera (fleas) and an ESW member since 1947. Of Dr. Traub's 156 peerless publications on ectoparasites, 9 have graced the pages of our *Proceedings.* The officers and members of the Entomological Society of Washington take this opportunity to wish Dr. Traub a full and speedy recovery from his current illness.

Gaye Williams exhibited elegant copper wire sculptures of a mosquito and a scorpion, both crafted by the Kentucky artist Ken Carns.

R. G. Robbins projected a series of color slides showing males and females of 10 African tick species in the genus *Amblyomma* that are known to be capable of transmitting heartwater (*Cowdria ruminantium*), a deadly rickettsial disease of livestock that occurs throughout sub-Saharan Africa and has become established in the eastern Caribbean. The slides were made directly from a set of beautiful drawings by A. Olwage, who illustrated the vectors of heartwater for a 1986 symposium published by the *Onderstepoort Journal of Veterinary Research* (54: 161–546, September 1987). A copy of this work was also exhibited.

The speaker for the evening was Marc Epstein, Postdoctoral Fellow, Department of Entomology, Smithsonian Institution, whose talk was entitled "Lepidopteran Slugs: A Natural History of the Limacodidae." Drawing on his extensive field experience, Dr. Epstein reviewed the morphological and developmental diversity in this pantropical family of some 1200 species. Limacodid larvae are ontogenetically remarkable: emerging from scale-like eggs, they are polyphagous but prefer late season, tannin-enriched foliage and undergo 7 strikingly dissimilar instars before pupating in solitary or communal pyriform cocoons.

Ben Pagac appealed for new subscribers to *Cicindela,* a quarterly journal devoted to tiger beetles that is now in its 20th year but whose future may be in jeopardy. Several back issues were displayed to the membership.

Visitors were introduced and the meeting was adjourned at 9:20 p.m. Refreshments followed.

Richard G. Robbins, *Recording Secretary*

## REPORTS OF OFFICERS

### Treasurer's Report

### SUMMARY FINANCIAL STATEMENT FOR 1988

| | General Fund | Special Publications Fund | Total Assets |
|---|---|---|---|
| Assets: November 1, 1987 | $13,839.27 | $66,051.13 | $79,890.40 |
| Total Receipts for 1988 | 60,899.98 | 7,105.05 | 68,005.03 |
| Total Disbursements for 1988 | 53,152.66 | 0.00 | 53,152.66 |
| Assets: October 31, 1988 | 21,586.59 | 73,156.18 | 94,742.77 |
| Net Changes in Funds | $ 7,747.32 | 7,105.05 | 14,852.37 |

Norman E. Woodley, *Treasurer*

### CORRESPONDING SECRETARY'S REPORT FOR 1988

Eight letters were written thanking guest speakers, 20 were sent to contributors to our Special Publication Fund, eight were sent in reply to requests for information, and 25 letters welcomed new members. The postage costs were $16.00.

John M. Kingsolver, *Corresponding Secretary*

### EDITOR'S REPORT

Fifty-eight articles, nine notes and eleven book reviews were published in The Proceedings in 1988 for a total of 532 pages. The Society paid page charges for four of the articles, and covered the cost of publishing all book reviews.

The variety of topics covered remained great. Many articles dealt with systematics of a group, while others discussed morphology, host-relations, or behavior. Although most authors were from the U.S., three first authors were from foreign countries.

The Editor wishes to thank the nearly seventy reviewers who assisted in improving all manuscripts. The Publications Committee and Book Review Editor were of special assistance during the year, as was the previous Editor.

Hiram G. Larew, *Editor*

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# MEMBERSHIP LIST OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON

The Bylaws of the Entomological Society of Washington require the Corresponding Secretary to publish a membership list every three years. The previous list was published February 1, 1986 with 632 members; the present list contains 547 members from every state in the union except Alaska, Arkansas, and Maine. The largest representation is in Maryland (91), followed by The District of Columbia (51), California (40), Florida (25), Virginia (22), and Pennsylvania (14). The figures for jurisdictions in the Washington, D.C. area are slightly skewed since several members receive their Proceedings at an office address. Twenty-two other countries in every continent except Antarctica are represented.

The format used in this list follows that of the 1986 list. Names of Honorary Members are capitalized, those of Emeritus Members are italicized, and Life Members are distinguished by an Asterisk (8) following the date they joined the Society. Dates of election to Honorary or Emeritus status are entered in parentheses. In 1988, Dr. Curtis W. Sabrosky was elected to Honorary President, and Dr. Louise Russell and Dr. Alan Stone were elected to Honorary membership.

I thank Dr. and Mrs. Wayne Mathis for their assistance in the preparation of this list. Any corrections to the list can be sent to the Corresponding Secretary at the address on the inside front cover of this issue. Corrections will be read at the next meeting of the Society, and will be published in the Proceedings by the Recording Secretary.

Abe, M. 1988 District of Columbia
Abercrombie, J. 1975 New York
Adams, J. R. 1963 Maryland
Adams, M. S. 1983 New York
Adamski, D. 1984 Mississippi
Adler, P. H. 1986 South Carolina
*Adler, V. E.* 1961 (1987) Maryland
*Aitken, T. H. G.* 1957 (1984) Connecticut
Aldrich, J. R. 1983 Maryland
Anderson, D. M. 1954 Maryland
*Anderson, L. D.* 1944 (1989) California
Anderson, W. H. 1937 Maryland
App, B. A. 1952 Florida
Appel, A. G. 1983 Alabama
Arduser, M. S. 1985 Missouri
Armitage, B. J. 1983 Alabama
Arnaud, P.H. 1955 California
Arnett, R. H., Jr. 1980 Florida
Arthur, A. P. 1988 CANADA
Ashlock, P. D. 1958 Kansas
Austin, D. F. 1977 Florida
Bacon, N. 1982 Pennsylvania
Baker, E. W. 1944 Maryland
Baker, G. T. 1987 Mississippi
Ball, G. E. 1948 CANADA
Barber, K. N. 1985 CANADA
Barnes, J. K. 1979 New York
Barnum, A. 1956 Utah
Barr, A. R. 1951 California
Barr, W. F. 1948 Idaho
Barrows, E. M. 1976 District of Columbia
Batra, S. W. T. 1985 Maryland
Baumann, R. W. 1973 Utah
Beal, R. S., Jr. 1958 Colorado
Bechtel, R. C. 1960 Nevada
Beck, T. R. 1979 Maryland
Becker, E. C. 1951 CANADA
Becker, V. O. 1987 BRAZIL
Bell, R. T. 1955 Vermont
Bellinger, R. G. 1972 South Carolina
Bergman, P. W. 1966 Virginia
Berry, R. L. 1972 Ohio
Bezark, L. G. 1974 California
Bicha, W. 1981 Ohio
Bickley, W. E. 1949* Maryland
BISSELL, T. L. 1941 (1983) Maryland
Blackburn, V. L. 1984 Maryland
Blom, P. E. 1986 Idaho
Boese, J. L. 1977 District of Columbia
Boettcher, R. A. 1955 District of Columbia
Bohart, R. M. 1944 California
Bohnsack, K. K. 1958 California
Boldt, P. E. 1987 Texas
Borkent, A. 1988 CANADA
Bouseman, J. K. 1988 Illinois

Bowen, T. W. 1980 North Carolina
Brigham, W. U. 1986 Illinois
Brou, V. A. 1985 Louisiana
Brown B. V. 1982 CANADA
Brown, F. M. 1975 Colorado
Brown, H. P. 1977 Oklahoma
Brown, R. L. 1979 Mississippi
Brushwein, J. R. 1987 Florida
Bueno-Soria, J. 1977 MEXICO
Burger, J. F. 1975 New Hampshire
Burke, H. R. 1981 Texas
Burks, B. D. 1938 Arizona
Burns, J. M. 1975* District of Columbia
Burrows, W. L. 1983 West Virginia
Butler, L. 1966 West Virginia
Byers, G. W. 1984 Kansas
Calabrese, D. M. 1981 New Jersey
Carlson, R. W. 1970* Maryland
Carmean, D. 1988 Oregon
Carpenter, J. M. 1984 Massachusetts
Carroll, J. F. 1977 Maryland
Casdorph, D. G. 1977 California
Cave, R. 1977 HONDURAS
Chapin, J. B. 1973 Louisiana
Charpentier, P. O. 1962 Connecticut
Chemsak, J. A. 1987 California
Chilson, L. M. 1977 Maryland
Chittick, H. A. 1946 New York
Christiansen, T. A. 1986 Wyoming
Clarke, W. E. 1975 Alabama
Clarke, J. F. G. 1936 District of Columbia
Clement, S. L. 1987 Washington
Cochran, D. G. 1981 Virginia
Coffman, C. C. 1980 West Virginia
Cohen, N. Y. 1983 Maryland
Cokendolpher, J. C. 1987 Texas
Connell, J. G. 1988 Indiana
Contreras-Ramos, A. 1986 Alabama
Cook, D. R. 1952 Michigan
Cooper, K. W. 1955 California
Corpus, L. D. 1985 Mississippi
Coulson, J.R. 1961 Maryland
Couri, M. S. 1987 BRAZIL
Courneya, P. 1986 Texas
Courtney, G. W. 1985 CANADA
Covell, C. V., Jr. 1986 Kentucky
Craig, G. B. 1954 Indiana
Cross, H. F. 1954 Georgia
Curčić, B. P. M. 1982 YUGOSLAVIA
Currado, I. 1978 ITALY
Darling, D. C. 1981 CANADA
Darsie, R. F., Jr. 1949 South Carolina
Davidson, J. A. 1957 Maryland
Davis, D. R. 1961 District of Columbia
Davis, J. R. 1985 Texas
Davis, L. G. 1952 Virginia
Davis, M. M. 1979 District of Columbia
Deeming, J. C. 1974* UNITED KINGDOM
Dietz, L. L. 1982 North Carolina
Dennis, S. 1979 Colorado
Deyrup, M. A. 1979 Florida
Dicke, F. F. 1933 Iowa
Dietrich, C. H. 1988 North Carolina
Dodson, G. 1987 AUSTRALIA
Donnelly, T. W. 1962 New York
Downes, W. G. 1981 Connecticut
Downes, W. L. 1985 Michigan
Doyen, J. T. 1983 California
Dozier, H. L. 1952* South Carolina
Drea, J. J. 1984 Maryland
*Drummond, R. O.* 1954 (1987) Texas
Durden, L. A. 1987 Maryland
Easton, E. R. 1985 South Dakota
Edmunds, G. F., Jr. 1951 Utah
Ehler, L. E. 1987 California
Eikenbary, R. D. 1979 Oklahoma
Eisenberg, R. M. 1988 Delaware
Elias, M. K. 1972 Maryland
Emerson, K. C. 1952 Florida
Enns, W. R. 1960 Missouri
Erwin, N. 1986 Maryland
Erwin, T. L. 1972 District of Columbia
Evans, E. W. 1984 Utah
Evans, H. E. 1948 Colorado
Evans, W. G. 1957 CANADA
Evenhuis, N. L. 1980 Hawaii
Fairchild, G. B. 1934 Florida
Fales, J. H. 1944 Maryland
Fee, F. D. 1983 Pennsylvania
Ferguson, D. C. 1969 District of Columbia
Fisher, E. M. 1977 California
*Fisk, F. W.* 1968 (1988) Florida
Flint, O. S., Jr. 1961 District of Columbia
Fluno, J. A. 1957 Florida
Foote, B. A. 1958 Ohio

Foote, R. H. 1950 Virginia
Forattini, O. P. 1956 BRAZIL
Foster, J. R. 1853 Maryland
Fox, I. 1936 Puerto Rico
Franclemont, J. G. 1947 New York
Freidberg, A. 1979 ISRAEL
Freytag, P. H. 1979 Kentucky
Gagne, R. J. 1966* District of Columbia
Gentry, J. W. 1958 Florida
Gerberg, E. J. 1953 Maryland
Ghorpade, K. 1986 INDIA
Gibson, L. P. 1981 Ohio
Giles, F. E. 1981 Maryland
Gill, G. D. 1958 Michigan
Gimpel, W. F., Jr. 1970 Maryland
Glaser, J. D. 1988 Maryland
Godfrey, G. L. 1971 Illinois
Goeden, R. D. 1982 California
Gordh, G. 1975 California
Gordon, R. D. 1968 District of Columbia
Gorham, J. R. 1974 District of Columbia
Grabowski, W. B. 1970 New Mexico
Grace, J. K. 1987 CANADA
Gregg, R. E. 1945 Colorado
Grissell, E. E. 1979 District of Columbia
Grogan, W. L. 1974 Maryland
Gunther, R. G. 1981 Illinois
Guzman, L. E. P. 1988 CHILE
Habeck, D. H. 1957 Florida
Hacker, J. D. 1971 West Virginia
Hagen, K. S. 1949 California
Haile, D. L. 1986 Pennsylvania
Haines, K. A. 1952 Virginia
Halstead, J. A. 1983 California
Hamilton, S. W. 1982 Tennessee
Hannemann, H.-J. 1979 EAST GERMANY
Hanson, P. 1985 COSTA RICA
Hansson, C. 1985 SWEDEN
Harbach, R. E. 1972 District of Columbia
Hardy, A. R. 1974 California
Harlan, H. J. 1988 Maryland
Harman, D. M. 1966 Maryland
Harris, S. C. 1979 Alabama
Harrison, B. A. 1976 District of Columbia
Harrison, S. J. 1985 Maryland
Haskins, C. P. 1945 District of Columbia
Hawkins, B. A. 1983 UNITED KINGDOM
Hayes, D. K. 1970 Maryland
Hendricks, H. J. 1987 Virginia
Hendrickson, R. M., Jr. 1978 Delaware
Henry, C. S. 1975 Connecticut
Henry, T. J. 1975 District of Columbia
Heppner, J. B. 1974 Florida
Heraty, J. M. 1986 Texas
Hespenheide, H. A., III 1981 California
Hevel, G. F. 1970 District of Columbia
Heydon, S. L. 1986 Maryland
Hodges, R. W. 1960* District of Columbia
Hoebeke, E. R. 1980 New York
Hoffmann, C. H. 1945 Maryland
Hoffman, K. M. 1986 South Carolina
Holzbach, J. E. 1983 Ohio
Holzenthal, R. W. 1985 Minnesota
Hoover, G. A. 1985 Pennsylvania
Hopla, C. E. 1961 Oklahoma
Hopper, H. P. 1978 District of Columbia
Howden, H. F. 1948 CANADA
Huang, Y.-M. 1968 District of Columbia
Hung, A. C. F. 1981 Maryland
Hurd, L. E. 1988 Delaware
Huryn, A. D. 1984 Georgia
Husband, R. W. 1973 Michigan
Imai, E. M. 1983 Maryland
Irwin, M. E. 1976 Illinois
Ivie, M. A. 1984 Montana
Jackson, D. L. 1966 Ohio
Jacobi, H. 1987 Maryland
Jakob, W. L. 1977 Colorado
*Jenkins, J. 1987 Michigan*
Johnson, J. B. 1987 Idaho
Johnson, M. D. 1973 Indiana
Johnson, N. F. 1980 New York
Johnson, P. J. 1984 Wisconsin
Jones, R. H. 1955 Colorado
Jones, S. R. 1985 Pennsylvania
Joseph, S. R. 1957 Maryland
Kaster, C. H. 1979 Michigan
Keirans, J. E. 1984 District of Columbia
Kelley, R. W. 1982 South Carolina
Kennedy, J. H. 1977 Texas
Kethley, J. B. 1874 Illinois
Kim, K. C. 1983 Pennsylvania
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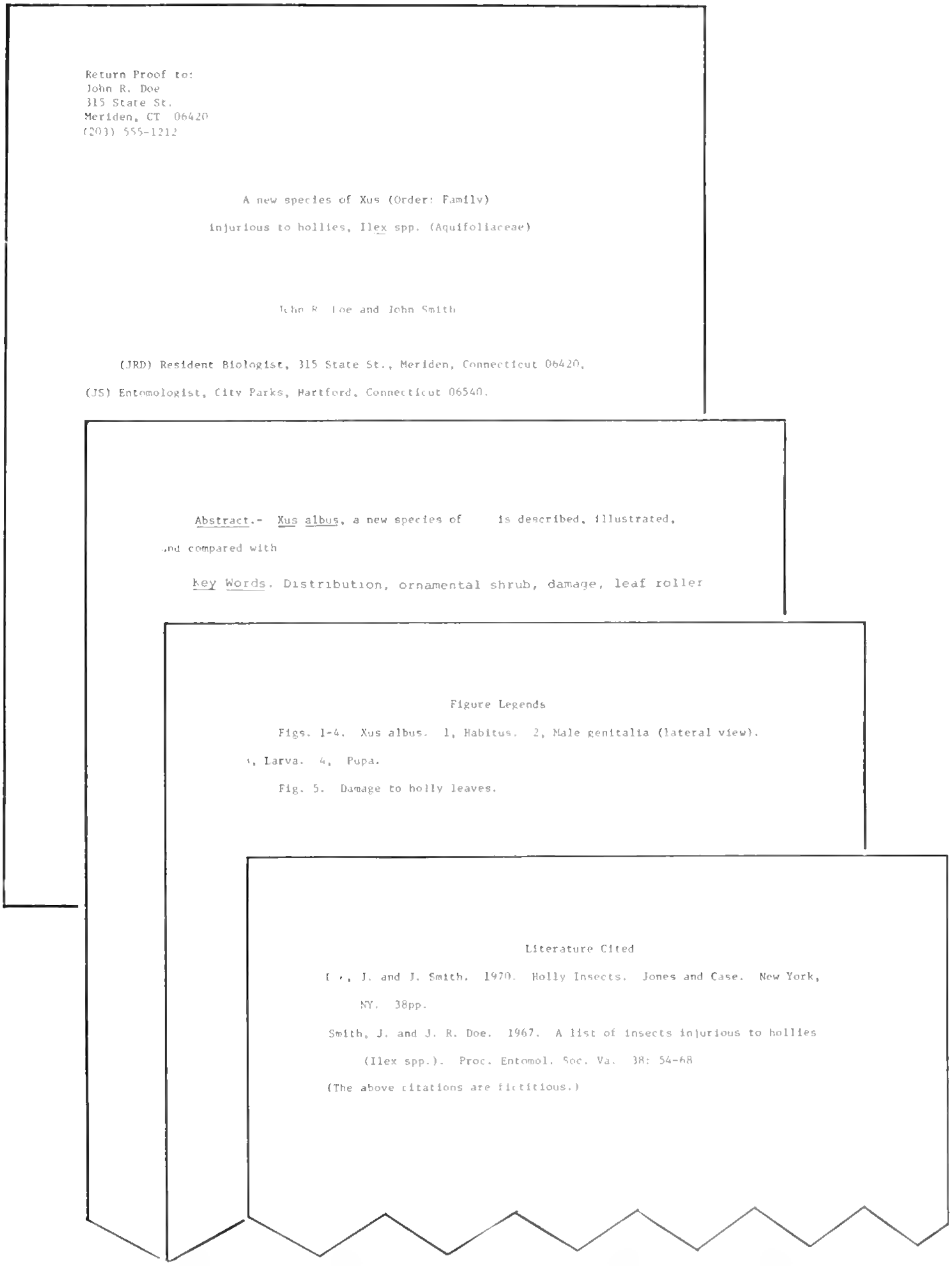

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A new species of Xus (Order: Family)

injurious to hollies, Ilex spp. (Aquifoliaceae)

John R. Doe and John Smith

(JRD) Resident Biologist, 315 State St., Meriden, Connecticut 06420,

(JS) Entomologist, City Parks, Hartford, Connecticut 06540.

Abstract.- Xus albus, a new species of is described, illustrated,

and compared with

Key Words. Distribution, ornamental shrub, damage, leaf roller

Figure Legends

Figs. 1-4. Xus albus. 1, Habitus. 2, Male genitalia (lateral view).

3, Larva. 4, Pupa.

Fig. 5. Damage to holly leaves.

Literature Cited

Doe, J. and J. Smith. 1970. Holly Insects. Jones and Case. New York,
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# A NEW SPECIES OF *DIORYCTRIA* (LEPIDOPTERA: PYRALIDAE: PHYCITINAE) FROM THE SOUTHEASTERN UNITED STATES

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*Abstract.*—***Dioryctria taedivorella***, a new species of coneworm, is described, illustrated and compared with *Dioryctria merkeli* Mutuura and Munroe.

*Key Words:* *Dioryctria,* coneworm, distribution, loblolly pine

Hedlin et al. (1981), in their investigation of cone and seed insects of North America, included nine species of *Dioryctria* Zeller in the southeastern United States. Recently, as a result of collecting and rearing efforts in North Carolina, and with the assistance of USDA Forest Service entomologists who supplied material from other southeastern states, we have been able to study larger series of *Dioryctria* and conclude that additional undescribed species occur in the region. In 1964, Neunzig et al., in publishing on *Dioryctria* in North Carolina, used the name *zimmermani* (Grote) for a species feeding in loblolly pine (*Pinus taeda* L.). They indicated, however, that the identification of this species was tentative and that additional taxonomic study was needed. Mutuura and Munroe (1979) were of the opinion that this North Carolina material, as well as specimens from elsewhere in much of the Southeast, belonged to their *Dioryctria merkeli.* Having compared the type of *D. merkeli,* on loan from the Canadian National Collection, with North Carolina specimens and other *Dioryctria* that are supposedly *merkeli,* we concluded: (1) the name *merkeli* should be restricted to certain populations of *Dioryctria* mainly feeding as larvae in slash pine (*Pinus elliotii* Engelmann) in northern Florida, southern Georgia and southern Mississippi, and (2) the similar, more northern and more widespread species, associated with loblolly pine, is new.

## ***Dioryctria taedivorella*, Neunzig and Leidy, New Species**

Figs. 1–6

Diagnosis.—*Dioryctria taedivorella* is most similar to *Dioryctria merkeli. D. taedivorella,* however, is a darker species with the antemedial and postmedial lines less distinct. These lines are chiefly white in *D. merkeli* and mostly gray in *D. taedivorella.* Also, the dorsum of the thorax of *D. taedivorella* is mostly brown to reddish brown, whereas the dorsum of the thorax of *D. merkeli* is mostly pale gray with few or no brown or reddish brown scales.

Description.—*Head:* frons mostly brown or fuscous, some scales white or tipped with white or gray, vertex reddish brown or brownish red. Labial palpus reaching above vertex in both sexes, mostly brown, fuscous or black with varying amounts of white, gray, reddish brown or brownish red. Maxillary palpus squamous, fuscous, white and gray. Antenna of male very weakly serrate with abundant sensilla trichodea. *Collar:* brown and reddish brown. *Thorax:* dorsum brown

Figs. 1–6. *Dioryctria taedivorella.* 3.5 × 1. Habitus, holotype. 2. Male genitalia, most of left valva and aedeagus omitted. 3, 4. Right valva, paratypes. 5. Aedeagus. 6. Female genitalia.

to reddish brown, sometimes with a few gray scales and usually with patches of fuscous or black scales; tufts of reddish brown scales posteriorly. *Forewing:* above with distinct, strongly raised scales forming subbasal, antemedial and postmedial patches; additional smaller patches of raised scales at base of wing and on discal spot; ground color brown; antemedial line obscure, formed of white-tipped gray scales (some scales suffused with red); postmedial line similar in color to antemedial line (medial part of line sometimes includes patch of fuscous or black-tipped scales); basal, subbasal, medial and terminal area with numerous reddish brown (usually rust-colored) scales; a few black scales in basal area (particularly part of small patch of raised scales), additional black scales basally and distally bordering antemedial line and expanding into broad dark patch along costa, basally and distally bordering postmedial line and forming large dark costal patch but weakly developed near inner margin, and forming terminal line. In addition to white-tipped gray scales of transverse lines, small patches of similarly colored scales near costa in basal half, in medial area and basad of terminal line; undersurface of male with no contrastingly-colored scales, or with a few brownish red scales near costa. Length of wing 12.0–15.0 mm. *Hindwing:* above, smoky gray, conspicuously darker along margins. *Male and female genitalia:* (Figs. 2–6) essentially like those of *D. merkeli.*

Type material.—Holotype, ♂, USA, N. CAROLINA, Lenoir Co., Kinston, US 70 Byp & Neuse R., 1-IX-1983, N. A. Leidy, *Pinus taeda* cone, emerg. 13-IX-1983, genitalia slide 895 HHN, in USNM. Paratypes 25 ♂, 51 ♀. USA, N. CAROLINA, Lenoir Co., Kinston, US 70 Byp & Neuse R., 28-VII-1983, 14-VIII-1983, N. A. Leidy, *Pinus taeda* cone, emerg. 8-IX-1983, 17-IX-1983, 6-X-1983, 12-X-1983, genitalia slides 872, 883, 893, 903 HHN (1 ♂, 3 ♀); USA, N. CAROLINA, Robeson Co., Lumberton, NC 211 4 mi W of I-95, J. B. Lattay Forest Tree Nur., 27-VII-1983, N. A. Leidy, host: *Pinus taeda* cone, emerg. 5-IX-1983, 10-IX-1983,

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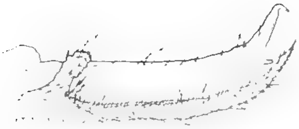

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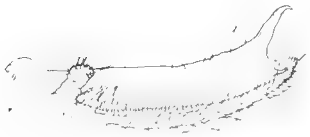

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X-1983, genitalia slides 885, 887, 891 HHN (3 ♂); USA, N. CAROLINA, Robeson Co., nr Lumberton, J. B. Lattay For. Nur., NC 211 4 mi W of I-95, 22-VII-1985, N. A. Leidy & M. Maynor, in *Pinus taeda* cone, emerg. 2-IX-1985 to 1-X-1985 (7 ♂, 8 ♀); USA, N. CAROLINA, Granville Co., Lewis, US 15 0.15 mi N of SR 1424, 18-VII-1985, N. A. Leidy, in *Pinus taeda* cone, emerg. 19-VIII-1985, 22-VIII-1985 (3 ♀); USA, N. CAROLINA, Wayne Co., Goldsboro, Claridge State For., SR 1326 1.5 mi

N of US 70, 15-VII-1985, N. A. Leidy, in *Pinus taeda* cone, emerg. 13-IX-1985 (1 ♂); USA, N. CAROLINA, Onslow Co., nr Richlands, NC 24 at SR 1230, 16-VII-1985, N. A. Leidy, in *Pinus taeda* cone, emerg. 21-IX-1985 (1 ♂); USA, N. CAROLINA, Onslow Co., nr Maysville, Hofmann Forest, 25-VI-1985, NA Leidy & DJ Lodge, in *Pinus taeda* cone, emerg. 11-IX-1985 (1 ♂); USA, S. CAROLINA, Berkeley Co., Francis Marion Seed Orchard, col. 23–27-VI-1983, 2nd year cones *Pinus taeda* (1 ♂, 2 ♀); USA, GEORGIA, Putnam Co., col. 9-VII-1985, emerg. 16-IX-1985, *Pinus taeda* (1 ♀); USA, ALABAMA, Greene Co., Weyerhaeuser Co., col. 1985, *Pinus taeda* (2 ♂, 10 ♀); USA, ALABAMA, Greene Co., Weyerhaeuser Co., col. 15-IX-86, emerg. 26-IX-86, 3-X-86, *Pinus taeda* (9 ♀); USA, ALABAMA, Greene Co., Weyerhaeuser Co., col. 15-IX-86, *Pinus taeda* (8 ♂, 14 ♀); USA, MISSISSIPPI, Perry Co., Erambert Seed Orchard, col. 16–20-VI-1986, 2nd yr. cone *Pinus taeda* (1 ♀). Paratypes deposited in USNM, NCSU and BMNH.

Distribution and life history.—Known from Virginia south to northern Florida and west to eastern Texas. The principal host is loblolly pine. Neunzig et al. (1964), under the name *D. zimmermani,* gave a detailed account of the biology of *D. taedivorella.*

Comments.—Although Mutuura and Munroe (1979) stated that their *D. merkeli* included populations associated with loblolly pine throughout most of the southeastern United States, they restricted their type series of *D. merkeli* to moths reared from slash pine growing in northern Florida, southern Mississippi, and southern Georgia.

## ACKNOWLEDGMENTS

We are especially grateful to H. O. Yates, USDA, Forest Service, for his interest and support. G. L. DeBarr and C. W. Fatzinger, USDA, Forest Service, and E. P. Merkel, USDA, Forest Service, retired, generously made available *Dioryctria* from Alabama, Florida, Georgia, Mississippi and South Carolina. We thank the following for assisting in the collection of *Dioryctria* in North Carolina: T. Hardin, Federal Paper Board Co., Lumberton; D. Lodge, formerly N.C. State University, Raleigh; M. Maynor, Federal Paper Board Co., Lumberton; D. Sparkman, Federal Paper Board Co., Lumberton; G. Turner, Claridge State Forest, Goldsboro; W. Wick, Champion Intl. Corp., Deppe. J. D. Lafontaine, Biosystematics Research Centre, Ottawa, Canada, sent the holotype of *D. merkeli* for study. Research funds were provided in part by the USDA, Forest Service. This is paper no. 11919 of the Journal Series of The North Carolina Agricultural Research Service, Raleigh, North Carolina 27695-7643.

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Neunzig, H. H., E. D. Cashatt, and G. A. Matuza. 1964. Observations on the biology of four species of *Dioryctria* in North Carolina (Lepidoptera: Phycitidae). Ann. Entomol. Soc. Amer. 57: 317–321.

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91(3), 1989, pp. 325–341

# TAXONOMIC STUDY OF THE LARVAE OF SIX EASTERN NORTH AMERICAN *DIORYCTRIA* (LEPIDOPTERA: PYRALIDAE: PHYCITINAE)

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*Abstract.*—Larvae of six eastern North American species of *Dioryctria* Zeller were examined using both a stereo light microscope and a scanning electron microscope (SEM). Detailed descriptions and a key to the species, supplemented with electron micrographs, are presented for the last instar larvae of *D. abietivorella* (Grote), *D. disclusa* Heinrich, *D. pygmaeella* Ragonot, *D. clarioralis* (Walker), *D. amatella* (Hulst), and *D. taedivorella* Neunzig and Leidy.

*Key Words:* Pyralidae, Phycitinae, *Dioryctria,* immatures, coneworm, taxonomy

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The genus *Dioryctria* Zeller is mostly Holarctic in distribution with a few species also occurring in the northern tropics. Fifteen species are known from eastern North America. Larvae feed exclusively on conifers.

The adults of the North American species of *Dioryctia* have been the subject of extensive taxonomic study beginning with Heinrich (1956) and Munroe (1959). In 1969, Mutuura, working in conjunction with several others, began a series of papers following up on Munroe's work (Mutuura, Munroe and Ross 1969a, b, Mutuura and Munroe 1972, 1973, 1974, 1979, Mutuura 1982, Mutuura and Neunzig 1986). Additional work on the adults has been done by Schaber and Wood (1971), Coulson et al. (1972), Blanchard and Knudson (1983) and Neunzig and Leidy (1989).

Although *Dioryctria* larvae have been briefly covered in various publications on forest pests, detailed descriptions of the larvae are few. MacKay (1943) described and figured the larvae of *D. reniculelloides* Mutuura and Munroe (as *D. reniculella* Grote), and briefly differentiated it from *D. abietivorella* (Grote) (as *D. abietella* Denis and Schiffermuller). Farrier and Tauber (1953) described and illustrated the larvae of *D. disclusa* Heinrich, and Lyons (1957) also described *D. disclusa* as well as *D. cambiicola* (Dyar) and *D. abietivorella* (as *D. abietella*). Neunzig et al. (1964), gave detailed descriptions of six species occurring in the southeastern United States: *D. amatella* (Hulst), *D. ebeli* Mutuura and Munroe (as *D. abietella*), *D. clarioralis* (Walker), *D. disclusa, D. taedivorella* Neunzig and Leidy (as *D. zimmermani* (Grote), and *D. pygmaeella* Ragonot. Schaber (1981) published on the larvae of *D. taedae* Schaber and Wood, however, larvae of *D. taedivorella* and *D. yatesi* Mutuura and Munroe were probably included in the described material.

Only two studies of *Dioryctria* have made use of scanning electron microscopy (SEM). Bradley et al. (1982) used SEM to examine the eggs of three species, *D. disclusa, D. amatella* and *D. ebeli.* The early-instar larvae of *D. reniculelloides* were examined by Spies and Dimond using SEM (1985).

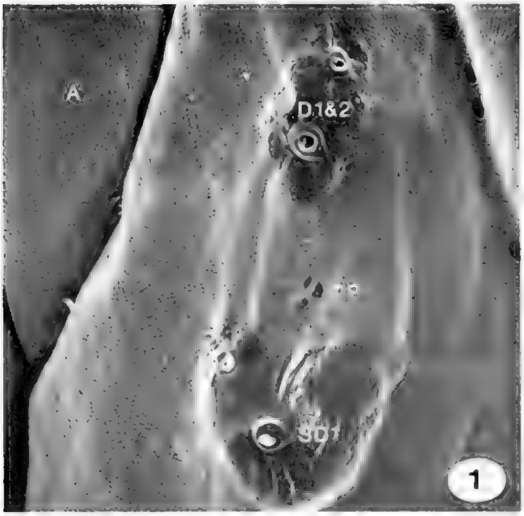


Fig. 1. Part of mesothorax including D and SD pinacula of *D. disclusa*, dorsolateral aspect. (150×). TP, tonofibrillary platelets; A, area shown enlarged in Figs. 22–27.

In this paper we update the descriptions of the last-instar larvae of six species by utilizing the conventional light microscope and the scanning electron microscope to reexamine the known diagnostic characters and to discover additional species differences.

Materials and methods.—*Dioryctria* larvae were collected in North Carolina from *Pinus taeda* L. (loblolly pine), *P. palustris* Miller (long-leaf pine), *P. echinata* Miller (short-leaf pine), *Taxodium distichum* (L.) (bald cypress), and *Abies fraseri* Pursh (Poiret) (Fraser's fir). Representative specimens of six species known to occur in eastern North America were obtained. Portions of each collection were preserved as larvae and the remainder reared to obtain adults. Descriptions of the color of the larvae were prepared immediately after fixing. The width of the head was measured at the widest point, and the length from the distal margin of the clypeus to the most posterior point of the epicranium. The median breadth of the spinneret was measured across its lateral surface.

Larvae to be examined using SEM were dissected in 40% ethanol. The head was removed, separated laterally at the point of mandible attachment, the mandibles removed, and the dorsal and ventral halves retained intact for the next several steps. Abdominal segments 9 and 10 and the left half of the thorax were also removed. The four pieces of tissue were brushed with a soft brush to remove loose debris, placed in a 50:50 solution of 10% Tween® 20 and 40% ethanol, and sonicated for five minutes. The tissue was then rinsed in 40% ethanol, brushed again, and transferred to flow-through capsules of Porex® Porous Plastic (Porex Technologies). It was then dehydrated in a graded series of ethanols (40%, 70%, 95%, 100%, 100%, 100%) and critical point dried using $CO_2$ in a Tousimis® Samdri®-PVT-3B. The dried tissue was then placed on studs using SPI® Conductive Carbon Paint (colloidal graphite in isopropanol 20% solids) and allowed to dry at least two days. Excess structures and tissue were removed using a hypodermic needle and all surfaces carefully brushed with a soft brush. The tissue was then coated with gold-palladium in a Technics Hummer V® sputter coater to a thickness of 25 nm, and observed with a JEOL JSM-T200® Scanning Electron Microscope (15 kV, WD 8, spot size 9). Micrographs were made using Polaroid® Type 55 P/N film. Setal nomenclature as given in Stehr (1987) is used for the body setae (Fig. 1). The terminology used for the mouthparts follows Crumb (1929) (Figs. 2, 3). The term tonofibrillary platelet is from Neunzig (1979). Terminology for the integument texture follows Eady (1968), Harris (1979), and Torre-Bueno (1978). A pair of structures on the epipharynx located mesad and slightly ventrad of epipharyngeal seta 1 were found to have not been named in the literature. They are herein referred to as epipharyngeal sclerites (Fig. 2). The margins of these sclerites are not clearly defined in electron micrographs but are generally visible under the light microscope and consistently

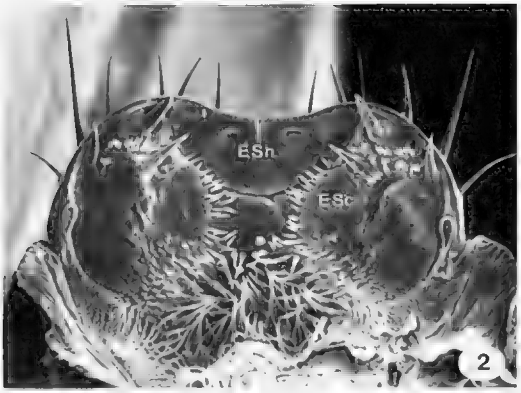


Fig. 2. Epipharynx of *D. amatella* (180×): ESc, epipharyngeal sclerites; ESh, epipharyngeal shield.

bare of spines, except occasionally on the mesal margin.

Common names of most species follow the Entomological Society of America (1982). The name fir coneworm for *D. abietivorella* is from Hedlin et al. (1981). Hedlin et al. (1981) also used the name loblolly pine coneworm for *D. merkeli* Mutuura and Munroe. In light of recent work (Neunzig and Leidy 1989), we suggest that the name loblolly pine coneworm would be better suited to *D. taedivorella,* as *D. merkeli* appears to feed chiefly on slash pine, *P. elliotii.* Scientific and common names of host plants follow Radford et al. (1968).

All intact immatures and adults have been placed as voucher specimens in the North Carolina State University Insect Collection (NCSU).

### *Dioryctria abietivorella* (Grote)
(fir coneworm)
Figs. 4, 10, 16, 22, 28

*Pinipestis abietivorella* Grote, 1878, Bulletin of the U.S. Geological and Geographical Survey of the Territories, 4: 701.

General.—Length 19.4 mm to 21.4 mm. Head reddish brown in epicranial area, shading to somewhat darker reddish brown near mandibles and hypostoma; tonofibrillary platelets indistinct; hypostoma reddish brown; antennal segments brown; mandibles reddish brown. Prothoracic shield translucent yellowish white anteriolaterally and mesally, remainder medium brown. Prespiracular plate yellowish brown, dark brown on posterior half of dorsal and ventral margins; tonofibrillary platelets medium to dark brown. Remainder of prothorax with brown granules dorsally and laterally, granules indistinct ventrally; hypodermal pigmentation yellowish white; tonofibrillary platelets yellowish white, shiny; pinacula light brown. Mesothorax, metathorax and abdomen with brown granules dorsally and laterally, granules indistinct ventrally; pinacula brown dorsally, paler brown to indistinct laterally and ventrally; tonofibrillary platelets yellowish white, shiny. Fused D2 pinacula of abdominal segment 9 yellow. Anal shield yellow mesally, brown laterally. Mesothoracic SD1 pinaculum forming ring, dark brown with large pale center.

Fig. 3. Hypopharynx of *D. disclusa,* dorsal aspect (300×): PmA, premaxillulary area; L, lingua; MX, lobes of the maxillulae; G, gorge of the maxillulae; B, blade of the maxillulae.

Eighth abdominal SD1 pinaculum forming ring, medium brown with small pale center. Setae brown basally, pale distally. Thoracic legs light brown laterally, yellowish white mesally. *Head:* Range of length and width respectively (in mm): 1.55–1.60, 1.88–1.95. Labrum with distal margin strongly indented. Epipharynx (Fig. 4) bare mesally from center to epipharyngeal shield, remainder with fine pale spines (lateral spines very short, in rows; mesal and basal spines longer, not in rows); epipharyngeal sclerites reddish brown; epipharyngeal shield somewhat narrow, pale brown. Hypopharynx (Fig. 10) with premaxillulary area bare; lobes of maxillulae bearing moderately slender spines; lingua bare; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, slightly darker anteriomesally; arms of mentum reddish brown. Spinneret slender, approximately 8.5× as long as median breadth. *Thorax:* SD1 on mesothorax 1.35 mm to 1.73 mm long. Integument of mesothorax areolate-rugose ventrade of D1&2 (Fig. 16); aerolate anterior to D1&2 (Figs. 16, 22). *Abdomen:* Seta D2 of abdominal segment 2 approximately ⅓ to ½ dorsoventral diameter of segment. SD1 of segment 8, 1.18 mm to 1.83 mm long. Crochets of abdominal prolegs biordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg.3: 42–62, seg.4: 52–56; seg.5: 54–62; seg.6: 48–64; seg.10: 43–47. Perianal region (Fig. 28) with short, slightly stout pale spines, spines dorsad of anus slightly longer and more slender than those laterad.

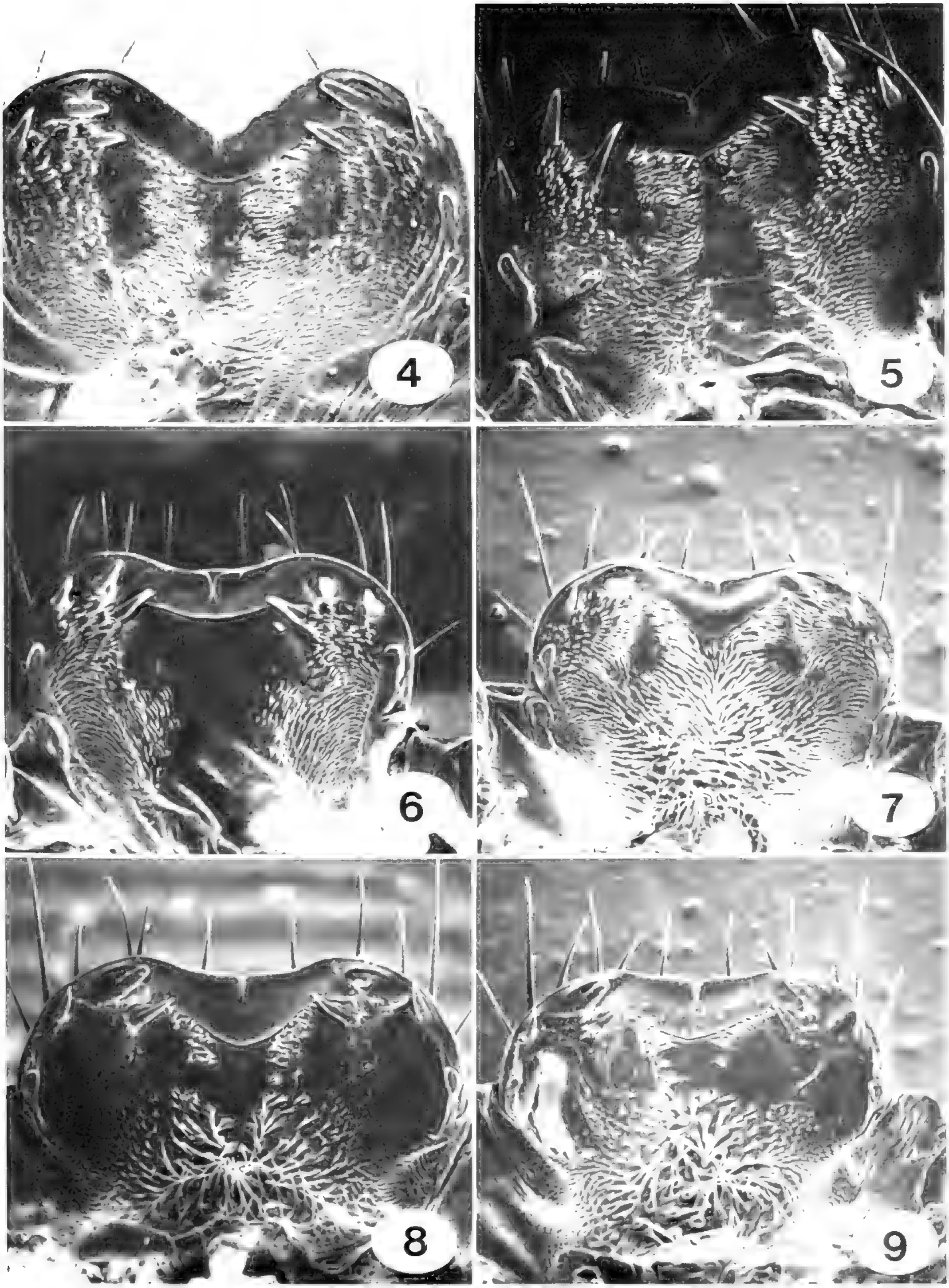
Materials examined.—Four larvae, USA N. Carolina: Mitchell Co., Bakersville, 28-X-1982, 21-VII-1983, 3-VIII-1983, W. Ayers. All larvae collected from *Abies fraseri.*

Comments.—In N.C. the larvae feed in the apical terminals and young branches of Fraser's fir, leaving a mass of frass, webbing, and needle fragments at the feeding site (Leidy and Neunzig 1986).

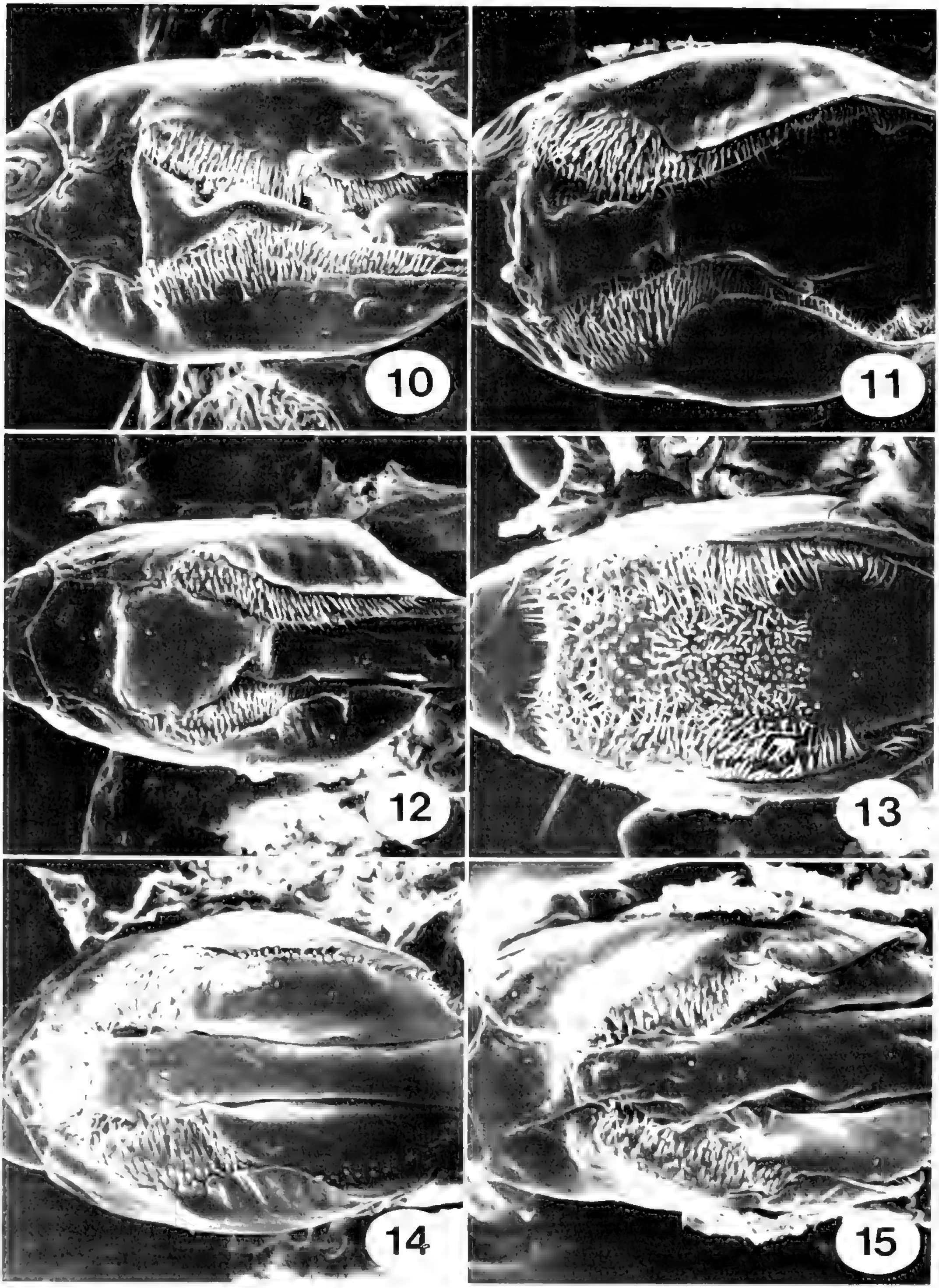
### *Dioryctria disclusa* Heinrich
(webbing coneworm)
Figs. 5, 11, 17, 23, 29

*Dioryctria disclusa* Heinrich, 1953, In Farrier and Tauber, Iowa State College Journal of Science, 27: 495.

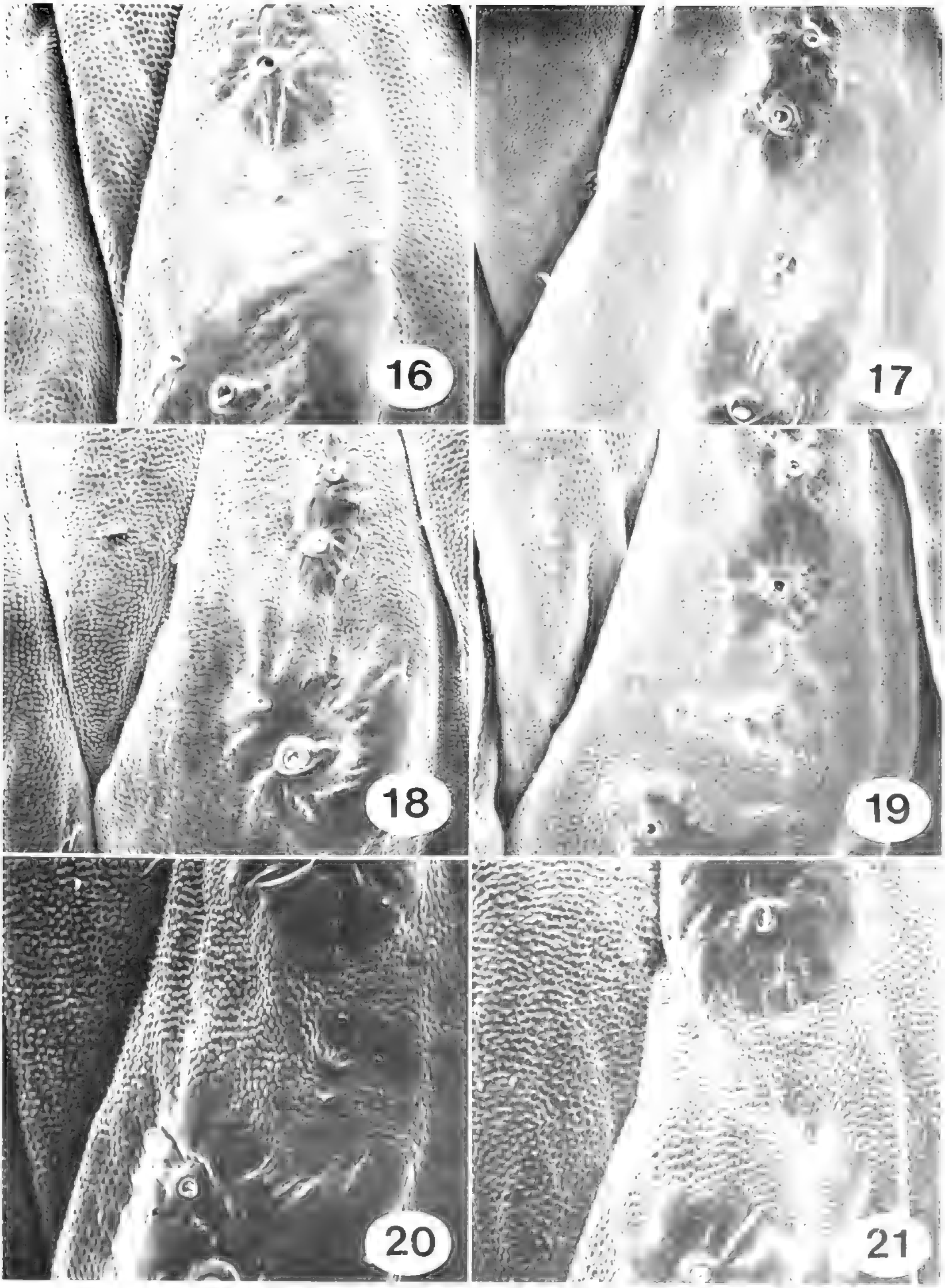
General.—Length 18.5 mm to 22.3 mm; moderately slender, at times slightly fusiform. Head reddish brown, sometimes with darker brown maculations; tonofibrillary platelets indistinct to dark brown; hypostoma dark reddish brown posteriorly, black anteriorly; antennal segments brown; mandibles reddish brown. Prothoracic shield pale yellowish brown anteriorly, pale mesally, remainder medium brown; tonofibrillary platelets dark brown. Prespiracular plate pale yellowish brown, dark brown on posterior half of dorsal and ventral margins; tonofibrillary platelets dark brown. Remainder of prothorax with gray granules dorsally and laterally; granules present ventrally but usually somewhat less prominent; hypodermal pigmentation buff; tonofibrillary platelets gray to buff, somewhat granular; pinacula light brown to buff. Mesothorax, metathorax and abdomen with gray granules dorsally, granules less distinct laterally and ventrally, or with gray granules dorsolaterally, granules less distinct mesally and laterally, appearing striped; hypodermal pigmentation buff; pinacula of mesothorax and metathorax pale brown to buff; pinacula of abdomen buff, indistinct except in contrast to granules; tonofibrillary platelets gray to buff, granular. Fused D2 pinacula of abdominal segment 9 yellowish brown. Anal shield yellowish brown. Mesothoracic SD1 pinaculum forming ring, light brown with large pale center. Eighth abdominal SD1 pinaculum forming ring, light brown with small pale center. Setae brown basally, pale distally. Thoracic legs medium to dark brown laterally, pale brown to yellowish white mesally. *Head:* Range of length



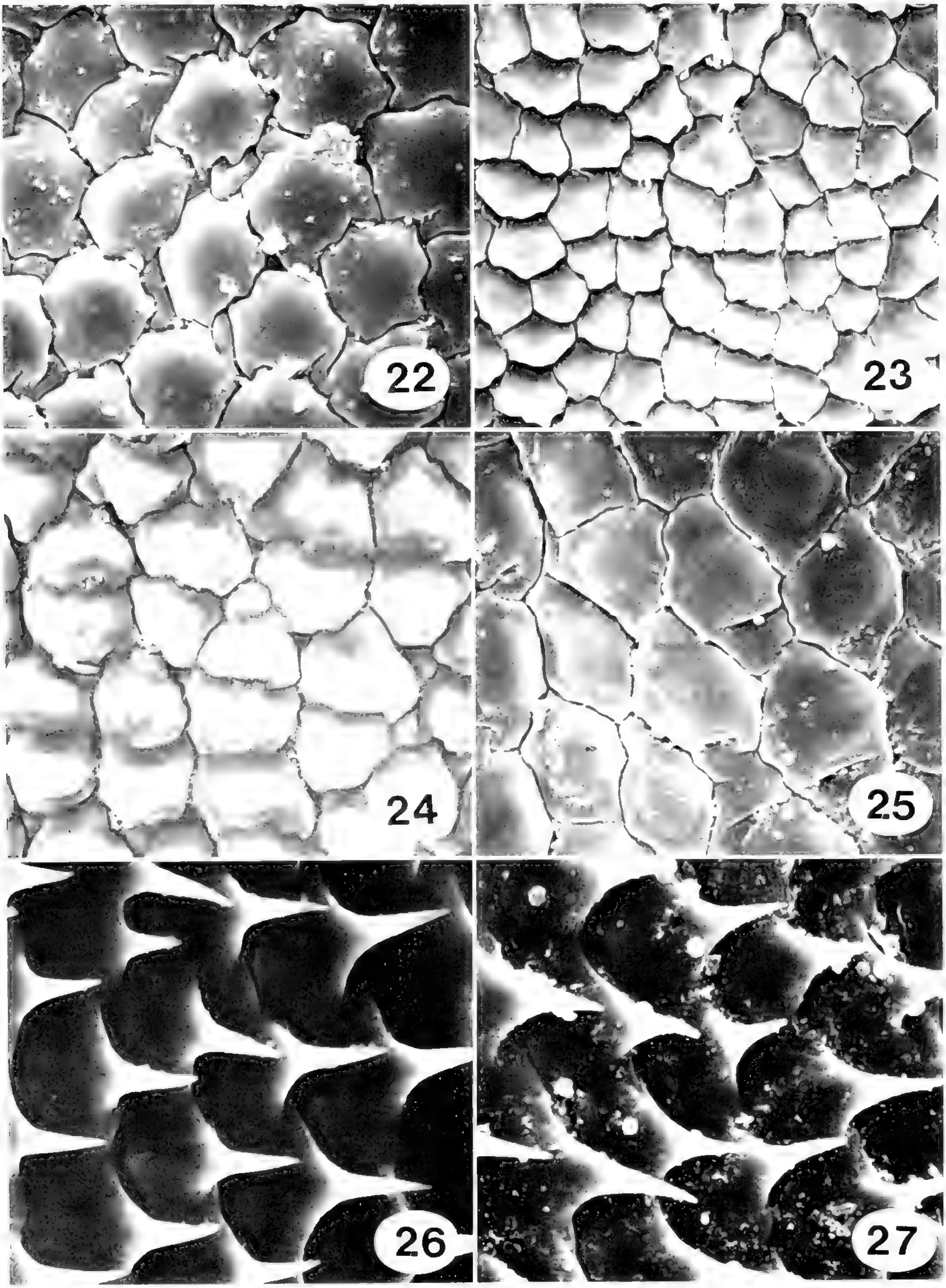
Figs. 4–9. *Dioryctria* spp. Epipharynx: 4. *D. abietivorella* (150×); 5. *D. disclusa* (150×); 6. *D. pygmaeella* (150×); 7. *D. clarioralis* (100×); 8. *D. amatella* (100×); 9. *D. taedivorella* (100×).



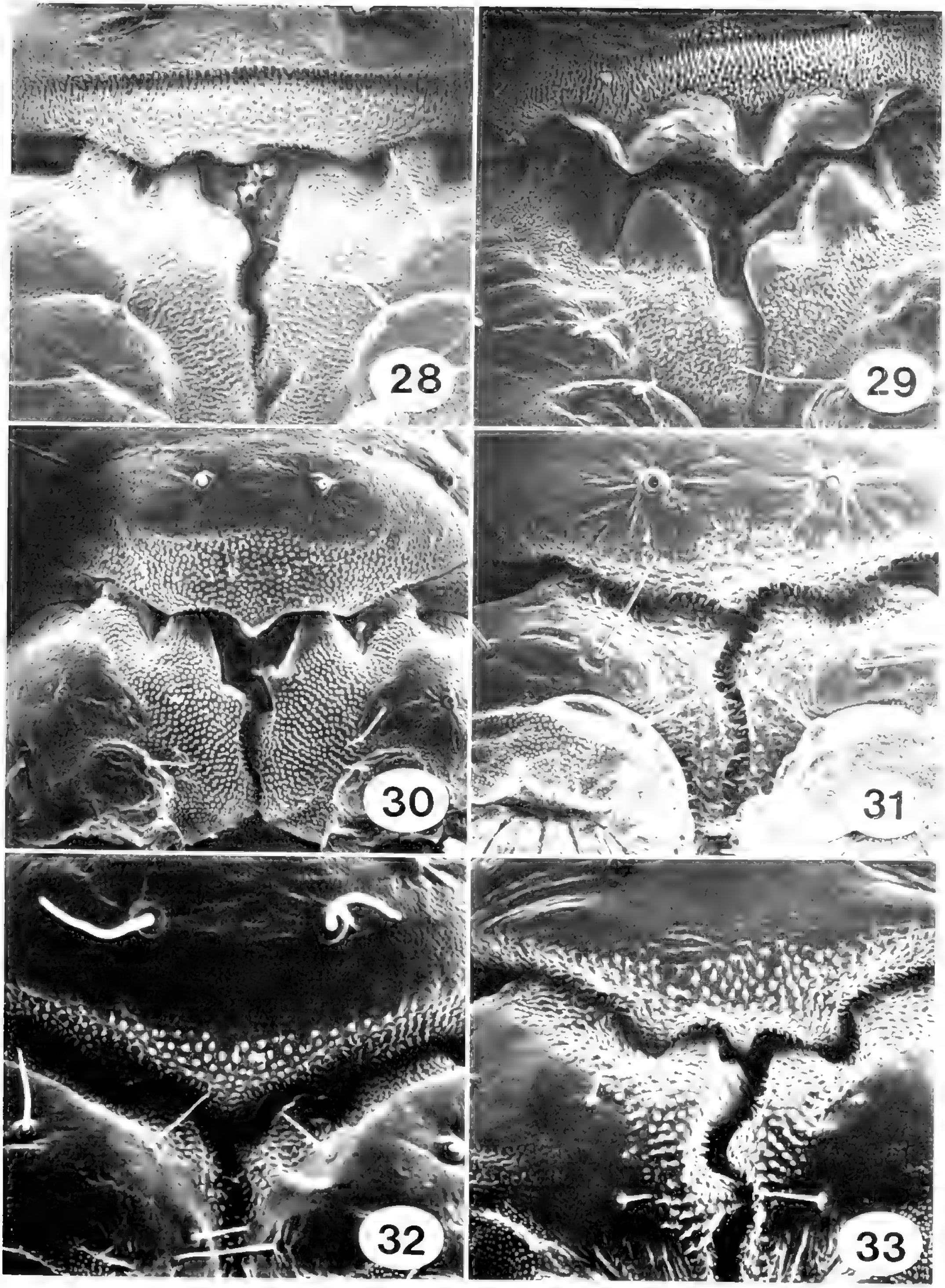
Figs. 10–15. *Dioryctria* spp. Hypopharynx, dorsal aspect: 10. *D. abietivorella* (200×); 11. *D. disclusa* (200×); 12. *D. pygmaeella* (200×); 13. *D. clarioralis* (150×); 14. *D. amatella* (150×); 15. *D. taedivorella* (150×).



Figs. 16–21. *Dioryctria* spp. Part of mesothorax including D and SD pinacula, dorsolateral aspect: 16. *D. abietivorella*; 17. *D. disclusa*; 18. *D. pygmaeella*, 19. *D. clarioralis*; 20. *D. amatella*; 21. *D. taedivorella* (100×)



Figs. 22–27. *Dioryctria* spp. Integument of mesothorax anterior to D1&2, dorsal aspect (see Fig. 1 for exact location): 22. *D. abietivorella*; 23. *D. disclusa*; 24. *D. pygmaeella*; 25, *D. clarioralis*; 26. *D. amatella*; 27. *D. taedivorella* (1500×)



Figs. 28–33. *Dioryctria* spp. Perianal region, caudal aspect. 28. *D. abietivorella*; 29. *D. disclusa*; 30. *D. pygmaeella*; 31. *D. clarioralis*; 32. *D. amatella*, 33. *D. taedivorella*. (75×)

and width respectively (in mm): 1.43–1.60, 1.60–1.78. Labrum with distal margin moderately indented. Epipharynx (Fig. 5) bare mesally to base and anterior to epipharyngeal sclerites; bearing short fine pale spines laterally and mesad of epipharyngeal sclerite; epipharyngeal sclerite indistinct; epipharyngeal shield narrow, reddish brown. Hypopharynx (Fig. 11) with premaxillulary area and lobes of maxillulae bearing long, moderately slender spines; lingua bare; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, black anteriomesally; arms of mentum reddish brown. Spinneret slender, approximately 7 × as long as median breath. *Thorax:* SD1 on mesothorax 1.13 mm to 1.55 mm long. Integument of mesothorax areolate ventrad of D1&2 (Fig. 17), squamiform anterior to D1&2 (Figs. 17, 23). *Abdomen:* Seta D2 of abdominal segment 2 approximately ¼ dorsoventral diameter of segment. SD1 of segment 8, 1.38 mm to 2.0 mm long. Crochets of abdominal prolegs mostly biordinal, occasionally partly triordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg.3: 53–78; seg.4: 60–74; seg.5: 57–76; seg.6: 59–75; seg.10: 46–65. Perianal region (Fig. 29) with short, light brown spines, spines dorsad of anus slightly longer and more slender than those laterad.

Material examined.—Twelve larvae. USA N. Carolina: Wayne Co., nr. Princeton, 30-IV-1985, N. A. Leidy; Johnston Co., nr. Princeton, 30-IV-1985, N. A. Leidy; Wayne Co., Goldsboro, 30-VI-1985, N. A. Leidy; Johnston Co., Clayton, 2-V-1985, N. A. Leidy; Bladen Co., Elizabethtown, 13-V-1985, N. A. Leidy; Wake Co., New Hill, 24-V-1984, Leidy & Richmond; Wake Co., Apex, 21-V-1984, N. A. Leidy. All larvae collected from *Pinus taeda.*

Comments.—The length of seta SD1 of the mesothorax and abdomen is at considerable variance from that reported by Neunzig et al. (1964) and figured by Farrier and Tauber (1953). It is consistent, however, in larvae from several dates and localities collected in 1985 and 1986. Larvae feed in ovulate cones leaving a mass of frass and webbing over the entry hole.

### *Dioryctria pygmaeella* Ragonot
### (baldcypress coneworm)
### Figs. 6, 12, 18, 24, 30

*Dioryctria pygmaeella* Ragonot, 1887, Diagnoses of North American Phycitidae and Galleriidae, 5.

General.—Length 11.1 mm to 15.1 (see comments); moderately slender, at times slightly fusiform. Head brown with darker brown maculations or uniformly dark brown; tonofibrillary platelets dark brown to indistinct; hypostoma dark brown; antennal segments dark brown; mandibles dark reddish brown. Prothoracic shield pale anteriorly and mesally, remainder light to medium brown with darker maculations or uniformly dark brown; tonofibrillary platelets dark brown to indistinct. Prespiracular plate light to dark brown; tonofibrillary platelets dark brown to indistinct. Remainder of prothorax with indistinct granules; hypodermal pigmentation pale yellow overlain with longitudinal white and pinkish orange stripes laterally, pale yellow ventrally; tonofibrillary platelets indistinct; pinacula dark brown at base of setae, remainder indistinct. Mesothorax, metathorax and abdomen with indistinct granules; hypodermal pigmentation pale yellow overlain with longitudinal white and pinkish orange stripes dorsally and laterally, pale yellow ventrally; pinacula dark brown at base of setae, remainder indistinct; tonofibrillary platelets indistinct. Fused D2 pinacula of abdominal segment 9 dark brown at base of setae, remainder pale yellowish brown to indistinct. Anal shield dark brown at base of setae, remainder pale yellowish brown. Mesothoracic SD1 pinaculum forming ring, dark brown with large pale center. Eighth abdominal SD1 pinaculum forming ring, dark brown with large pale center. Setae brown basally, pale distally. Thoracic legs dark brown. *Head:* Range of length and width respectively (in mm): 1.13–1.25, 1.28–1.55. Labrum with distal margin moderately indented. Epipharynx bare mesally to base, bearing short fine pale spines laterally (Fig. 6), occasionally bare mesad of epipharyngeal sclerites, bearing short fine pale spines mesally at base and laterally; epipharyngeal sclerites indistinct; epipharyngeal shield narrow, pale distally, brown proximally and mesally. Hypopharynx with premaxillulary area bare; lobes of maxillulae bearing moderately slender spines distally, longer slender spines proximally; lingua bare; blades of maxillulae simple; gorge of maxillulae bare (Fig. 12), occasionally bearing slender spines distally; mentum brown, darker anteriomesally; arms of mentum brown. Spinneret slender, approximately 6× as long as median breadth. *Thorax:* SD1 on mesothorax 1.25 mm to 1.60 mm long. Integument of mesothorax areolate-rugose ventrad of D1&2 (Fig. 18); tuberculate-squamiform anterior to D1&2 (Figs. 18, 24). *Abdomen:* Seta D2 of abdominal segment 2 approximately ⅓ the dorsoventral diameter of the segment. SD1 of segment 8, 1.30 mm to 1.90 mm long. Crochets of abdominal prolegs partly biordinal, partly triordinal, arranged in a circle. Number of crochets of abdominal prolegs: seg.3: 48–68; seg.4: 50–69; seg.5: 50–70; seg.6: 50–72; seg.10: 33–49. Perianal region with short, peg-like pale to light brown spines (Fig. 30).

Material examined.—Fourteen larvae. USA N. Carolina: Currituck Co., Coinjock, 14-VII-1986, N. A. Leidy; Currituck Co., Coinjock, 17-VIII-1978, L. Grimes; Bladen Co., Singletary Lake State Park (collected by permit) 23-VII-1985, N. A. Leidy. All larvae collected from *Taxodium distichum.*

Comments.—The epipharynx and hypopharynx show considerable variation in spinulation; however, both variations occur in larvae from the same site and collection date, and other larval characters and associated reared adults give no reason to suspect two separate species. Three larvae had an overall length of 11.1 mm to 11.8 mm. These larvae were borrowed material which had been stored for several years in 80% ethanol and may have dessicated and shrunk slightly. Freshly preserved larvae ranged from 12.7 mm to 15.1 mm. All larval feeding records are from bald cypress ovulate cones.

### *Dioryctria clarioralis* (Walker)
### (blister coneworm)
### Figs. 7, 13, 19, 25, 31

*Nephopteryx* (sic) *clarioralis* Walker, 1863, List of the Specimens of Lepidopterous Insects in the Collection of the British Museum, 27: 54.

General.—Length 20.1 mm to 20.2 mm, moderately slender. Head reddish brown with dark brown maculations (uniformly dark brown); tonofibrillary platelets dark brown (indistinct); hypostoma reddish brown (dark brown); antennal segments brown; mandibles reddish brown. Prothoracic shield pale anteriorly and mesally, remainder pale yellowish brown (dark brown); tonofibrillary platelets dark brown. Prespiracular plate pale yellowish brown (dark brown, pale on anterior and ventral margins); tonofibrillary platelets dark brown. Remainder of prothorax with gray granules dorsally and laterally, granules present ventrally but somewhat less prominent; hypodermal pigmentation yellowish white, tonofibrillary platelets gray, somewhat granular; pinacula yellowish white and indistinct to pale brown. Mesothorax, metathorax and abdomen with gray granules dorsally, granules less distinct laterally and ventrally; hypodermal pigmentation yellow overlain with pale rose giving an overall pale orange appearance; pinacula pale yellow, indistinct (pale brown); tonofibrillary platelets pale gray, somewhat granular. Fused D2 pinacula of abdominal segment 9 pale yellow. Anal shield pale yellow. Mesothoracic SD1 pinaculum forming incomplete ring, pale yellow (brown) with large pale center. Eighth abdominal SD1 pinaculum forming ring, pale yellow (brown) with large pale center. Setae brown basally, pale distally. Thoracic legs pale brown (dark brown) laterally, yellowish white mesally. *Head:* Length and width respectively (in mm): (specimen 1) 1.62, 1.75; (specimen 2) 1.50, 1.60. Labrum with distal margin moderately indented. Epipharynx (Fig. 7) bearing short slender pale spines laterally, longer slender pale spines mesally; epipharyngeal sclerites pale reddish brown; epipharyngeal shield large, pale brown. Hypopharynx (Fig. 13) with premaxillulary area, lobes of maxillulae, lingua, and gorge of maxillulae anteriorly bearing pale spines, spines somewhat short mesally, longer laterally and anteriorly; gorge of maxillulae bare posteriorly; blades of maxillulae simple; mentum brown, darker anteriomesally; arms of mentum brown. Spinneret slender, approximately 6 × as long as median breadth. *Thorax:* SD1 on mesothorax 0.60 mm to 0.67 mm long. Integument of mesothorax areolate ventrad of D1&2 (Fig. 19), areolate anterior to D1&2 (Figs. 19, 25). *Abdomen:* Seta D2 of abdominal segment 2 approximately ⅐ dorsoventral diameter of segment. SD1 of segment 8, 0.60 mm to 0.73 mm long. Crochets of abdominal prolegs mostly triordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg. 3: 76–80; seg. 4: 68–70; seg. 5: 76–78; seg. 6: 80–82; seg. 10: 49–51. Perianal region (Fig. 31) with coarse pale (medium brown) spines.

Material examined.—Two larvae. USA N. Carolina: Wake Co., 27-VI-1986, N. A. Leidy; Wayne Co., Goldsboro, 14-I-1987, J. A. Smith. Larvae collected from *Pinus taeda.*

Comments.—Only two larvae of *D. clarioralis* were obtained. One larva was reared by placing a gravid light-trapped female in a sleeve cage over a branch of *P. taeda* bearing developing ovulate cones and allowing her to lay eggs. This larva forms the basis of the above description. A second larva obtained in Jan. 1987, from damaged host material has been included but varies considerably from the first larva in coloration of the pigmented, sclerotized structures. It is also more slender but head capsule and setal measurements indicate a last-instar larva. Variations are indicated parenthetically above. The differences in size and pigmentation are probably due to the colder average temperature at which this larva developed. Larvae feed in ovulate cones or branch terminals leaving a blister of resin-coated webbing and frass over the entry hole.

### *Dioryctria amatella* (Hulst)
### (southern pine coneworm)
### Figs. 8, 14, 20, 26, 32

*Nephopteryx* (sic) *amatella* Hulst, 1878, Entomologica Americana, 3(7): 131.

General.—Length 19.5 mm to 25.4 mm; moderately robust. Head light to medium reddish brown; tonofibrillary platelets indistinct; hypostoma reddish brown; antennal segments brown; mandibles dark reddish brown. Prothoracic shield pale brown to yellow anteriorly, pale brown to brown mesally with pale longitudinal stripe, remainder dark brown; tonofibrillary platelets dark brown. Prespiracular plate dark brown, tonofibrillary platelets black, shiny. Remainder of prothorax with brown granules dorsally and laterally, granules present ventrally, but indistinct; hypodermal pigmentation greenish white to pale green ventrad of tonofibrillary platelets, remainder greenish white to pale green overlain with rose; tonofibrillary platelets black, shiny; pinacula brown to indistinct. Mesothorax, metathorax and abdomen with brown granules dorsally, granules less distinct laterally, indistinct ventrally; hypodermal pigmentation greenish white to pale green ventrad of tonofibrillary platelets, remainder greenish white to pale green heavily overlain with rose dorsally, rose less distinct laterally and ventrally; pinacula dark brown dorsally to pale brown ventrally; tonofibrillary platelets black, shiny. Fused D2 pinacula of abdominal segment 9 pale to medium yellowish brown. Anal shield pale to medium yellowish brown. Mesothoracic SD1 pinaculum forming ring, dark brown with minute pale center. Eighth abdominal SD1 pinaculum not forming ring, unicolorous dark brown. Setae brown basally, pale distally. Thoracic legs pale mesally, dark laterally. *Head:* Range of length and width respectively (in mm): 1.62–2.10, 2.05–2.35. Labrum with distal margin slightly indented. Epipharynx (Fig. 8) at base with numerous pale, stout spines mesally; epipharyngeal sclerite pale reddish brown; epipharyngeal shield large, dark brown. Hypopharynx (Fig. 14) with premaxillulary area, lingua and lobes of maxillulae bearing coarse spines; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, dark brown anteriomesally extending anteriorly to lingua; arms of mentum brown. Spinneret relatively stout, approximately 5× as long as median breadth. *Thorax:* SD1 on mesothorax 0.75 mm to 1.02 mm long. Integument of mesothorax tuberculate ventrad of D1&2 (Fig. 20); spinose anterior to D1&2 (Figs. 20, 26). *Abdomen:* Seta D2 of abdominal segment 2 approximately ¼ dorsoventral diameter of segment. SD1 of segment 8, 0.77 mm to 0.97 mm long. Crochets of abdominal prolegs mostly biordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg. 3: 52–64; seg. 4: 54–62; seg. 5: 46–64; seg. 6: 48–60; seg. 10: 29–39. Perianal region with coarse pale spines (Fig. 32).

Material examined.—Sixteen larvae. USA N. Carolina: Richmond Co., Rockingham, 4-VIII-1985, 6-VIII-1986, N. A. Leidy; Moore Co., Southern Pines, 4-VIII-1985, 14-VIII-1983, N. A. Leidy; Onslow Co., Richlands, 16-VII-1985, N. A. Leidy. Larvae collected primarily from *Pinus palustris,* a few collected from *P. taeda.*

Comments.—Although the perianal spines of *D. amatella* (Fig. 32) are in size actually very similar to those of *D. taedivorella* (Fig. 33), they appear more slender when viewed with the light microscope because of their pigmentation. Larvae of the spring generation on *P. palustris* often feed within the branch terminals, leaving masses of pitch mixed with some frass over the entry hole. Later generations on *P. palustris* feed in the ovulate cones, leaving large masses of pitch mixed with frass over the entry hole. Larvae feeding in the ovulate cones of *P. taeda* were not observed to leave masses of pitch at the entry hole.

### *Dioryctria taedivorella* Neunzig and Leidy
### (loblolly pine coneworm)
Figs. 9, 15, 21, 27, 33

*Dioryctria taedivorella* Neunzig and Leidy, 1989, Proc. Entomological Society of Washington, 91: 321–324.

General.—Length 18.6 mm to 23.4 mm; moderately robust. Head medium to dark reddish brown occasionally with slightly darker maculations; tonofibrillary platelets indistinct; hypostoma dark reddish brown; antennal segments brown; mandibles dark reddish brown. Prothoracic shield pale yellow anteriorly and mesally, remainder dark brown, occasionally paler brown posteriorly; tonofibrillary platelets dark brown. Prespiracular plate brown to dark brown; tonofibrillary platelets black. Remainder of prothorax with dark brown granules dorsally and laterally; granules present ventrally but less prominent and pale; hypodermal pigmentation pale green ventrad of tonofibrillary platelets, remainder pale green overlain with rose; tonofibrillary platelets black, shiny; pinacula dark brown dorsally to pale brown ventrally. Mesothorax, metathorax and abdomen with dark brown granules dorsally and laterally, granules less distinct ventrally; hypodermal pigmentation pale green ventrad of tonofibrillary platelets, remainder rose; pinacula dark brown dorsally to pale brown ventrally; tonofibrillary platelets black, shiny. Fused D2 pinacula of abdominal segment 9 yellowish brown to reddish brown, occasionally darker marginally. Anal shield yellowish brown to reddish brown mesally, reddish brown to dark brown laterally. Mesothoracic SD1 pinaculum forming ring dark brown with minute, pale center. Eighth abdominal SD1 pinaculum not forming ring, unicolorous dark brown. Setae brown basally, pale distally. Thoracic legs pale mesally, dark brown laterally. *Head:* Range of length and width respectively (in mm): 1.62–1.80, 1.95–2.18. Labrum with distal margin slightly indented. Epipharynx (Fig. 9) at base with numerous dark reddish brown tipped, stout spines mesally; epipharyngeal sclerites reddish brown; epipharyngeal shield large, dark reddish brown, nearly black slightly paler mesally. Hypopharynx (Fig. 15) with premaxillulary area and lobes of maxillulae bearing coarse spines; lingua bare to a few spines; blades of maxillulae simple; gorge of maxillulae bare; mentum reddish brown, black anteriomesally, extending anteriorly to lingua; arms of mentum reddish brown. Spinneret stout, approximately 4× as long as median breadth. *Thorax:* SD1 on mesothorax 0.62 mm to 0.87 mm long. Integument of mesothorax tuberculate-rugose ventrad of D1&2 (Fig. 21); spinose anterior to D1&2 (Figs. 21, 27). *Abdomen:* Seta D2 of abdominal segment 2 approximately ⅕ dorsoventral diameter of segment. SD1 of segment 8, 0.70 mm to 0.82 mm long. Crochets of abdominal prolegs mostly biordinal, arranged in a circle. Number of crochets on abdominal prolegs: seg. 3: 42–60; seg. 4: 46–62; seg. 5: 39–60; seg. 6: 45–64; seg. 10: 35–49. Perianal region (Fig. 33) with coarse, dark tipped spines.

Material examined.—Seventeen larvae. USA N. Carolina: Onslow Co., Maysville, 25-VI-1985, Leidy & Lodge; Wayne Co., Goldsboro, 16-VII-1985, N. A. Leidy; Granville Co., Lewis, 18-VII-1985, N. A. Leidy; Onslow Co., Richlands, 16-VII-1985, N. A. Leidy; Robeson Co., Lumberton, 27-VII-1983, N. A. Leidy; Lenoir Co., Kinston, 14-VII-1985, N. A. Leidy; Robeson Co., Lumberton, 22-VII-1985, Leidy & Maynor; Robeson Co., Lumberton, 9-VII-1986, Leidy & Hardin. Larvae collected from *Pinus taeda.*

Comments.—Larvae feed in ovulate cones, occasionally leaving small amounts of resin and frass at the entry hole. Damaged cones turn brown before maturing and do not open.

Discussion.—New information on the larvae of *Dioryctria,* particularly with respect to spinulation of the trophi and perianal region, and the texture of the integument was revealed using SEM. The spines of the epipharynx of *D. pygmaeella* (Fig. 6) and *D. disclusa* (Fig. 5) were easily observed using SEM, but difficult to see with the light microscope, because they lack strong pigmentation. Neunzig et al. (1964), using conventional methods, did not observe these spines. Similarly, SEM revealed numerous spines on the lobes of the maxillulae of *D. pygmaeella* (Fig. 12) although Neunzig et al. (1964) described the hypopharynx of *D. pygmaeella* as "bare or with a few indistinct spines." The perianal region of *D. pygmaeella* was also described by Neunzig et al. (1964) as "lacking distinct spines"; however, SEM showed considerable spinulation (Fig. 30). Additionally, Neunzig et al. (1964) separated *D. amatella* (Fig. 32) and *D. taedivorella* (Fig. 33) (as *zimmermani*) partly on the basis of the appearance of the perianal spines; however, electron micrographs of this region in the two species showed little difference. The variation observed with the light microscope is apparently due to pigmentation, not relative size of the spines.

The appearance of other structures also varied depending on the method of observation. The epipharyngeal shield was apparent with either method, but the epipharyngeal sclerites, quite prominent under the light microscope on some species because of their pigmentation, were not distinct using SEM. Their location could be established in species with the epipharynx heavily spinose, such as *D. clarioralis* (Fig. 7), because of the absence of spines on the sclerites. In species such as *D. amatella* (Fig.

8), however, with only a few spines in the general area, there is no real indication of a structure.

The tonofibrillary platelets of the mesothorax also appeared quite dissimilar depending on the method of observation. Those of *D. taedivorella* (Fig. 21) were apparent using SEM because of their indentation and difference in texture from the surrounding integument, but they are even more striking under the light microscope because of their black pigmentation. In contrast, the tonofibrillary platelets of *D. disclusa* (Fig. 17) were more distinct using SEM than in light microscopy.

SEM also made more apparent major variation in the texture of the integument. The mesothorax anterior to setae D1&2 of *D. amatella* (Fig. 26) and *D. taedivorella* (Fig. 27) is spinose, whereas it ranges from areolate in *D. abietivorella* (Fig. 22) and *D. clarioralis* (Fig. 25) to squamiform in *D. disclusa* (Fig. 23) and tuberculate-squamiform in *D. pygmaeella* (Fig. 24).

Mutuura and Munroe (1972, 1974) placed the adults of *Dioryctria* in eight species groups. Most of the species which we studied were assigned (Mutuura and Munroe 1972, 1974, 1979) to four of these as follows: abietella group: *D. abietivorella*; auranticella group: *D. disclusa*; baumhoferi group: *D. pygmaeella*; and zimmermani group: *D. amatella*. *D. clarioralis* and *D. taedivorella* were not included by Mutuura and Munroe, but obviously the former belongs to the baumhoferi group and the latter to the zimmermani group. Our study of *Dioryctria,* although treating relatively few species, gives evidence that most of the larvae can also be placed in the proposed groups. Both species of the zimmermani group have very similar spinulation of the epipharynx (Figs. 8, 9), hypopharynx (Figs. 14, 15), and perianal region (Figs. 32, 33), as well as similar integumental texture (Figs. 26, 27). Additionally, each has black tonofibrillary platelets and a unicolorous SD1 pinaculum on the eighth abdominal segment. The remaining species can be readily separated from one another as larvae. There are distinct differences in the texture of the integument of *D. abietivorella* (Fig. 22) and *D. disclusa* (Fig. 23). In addition, the pigmentation of the D1 and D2 pinacula of the abdominal segments, and the length of seta D2 of the abdominal segments further separate these two species. As mentioned, *D. pygmaeella* has been placed in the baumhoferi group. Mutuura and Munroe (1972) noted, however, that their placement of *D. pygmaeela* was tentative because of differences in the male genitalia. Examination of the larval characters also casts doubt on the placement of *D. pygmaeella* in the baumhoferi group. Variation in the spinulation of both the hypopharynx (Figs. 12, 13) and perianal region (Figs. 30, 31) of *D. pygmaeella* and *D. clarioralis* is considerable. Differences are also found in the texture of the integument (Figs. 24, 25). Blanchard and Knudson (1983) recently described a new species from Texas, *D. caesirufella,* which they feel is most closely allied with *D. pygmaeella.* Although larvae of *D. caesirufella* were not available for this study, the dissimilarity of the larvae of *D. pygmaeella* and *D. clarioralis* suggest that *D. pygmaeella* may be better placed with *D. caesirufella* in a new species group, rather than in the baumhoferi group.

## KEY TO LAST-INSTAR LARVAE OF EASTERN NORTH AMERICAN SPECIES OF *DIORYCTRIA*

1. Tonofibrillary platelets of abdomen pale, differing in texture from, or only slightly darker than, integument; pinaculum SD1 of 8th abdominal segment forming ring with pale center; integument not spinose anterior to D1&2 of mesothorax (Figs. 16–19, 22–25) ......... 2
– Tonofibrillary platelets of abdomen black, shiny; pinaculum SD1 of 8th abdominal segment not forming ring, unicolorous dark brown; integument spinose anterior to D1&2 of mesothorax (Figs. 20, 21, 26, 27) .............. 5
2. Pinacula D1 & D2 of abdomen brown, at least at base of setae; seta D2 of abdominal segments long, ⅓ to ½ dorsoventral diameter of segment ................................ 3

– Pinacula D1 & D2 of abdomen usually pale, appearing lighter than surrounding integument; seta D2 of abdominal segments short, ⅓ to ¼ dorsoventral diameter of segment ..... 4

3. Tonofibrillary platelets yellowish white, shiny, distinct from integument; pinaculum SD1 of 8th abdominal segment with small pale center; labrum with distal margin distinctly indented (Fig. 4); overall length approximately 20 mm ................................... *abietivorella*

– Tonofibrillary platelets indistinct; pinaculum SD1 of 8th abdominal segment with large pale center; labrum with distal margin weakly indented (Fig. 6); overall length approximately 13 mm ......................... *pygmaeella*

4. Pinaculum SD1 of 8th abdominal segment with small pale center; pinaculum SD1 of mesothorax forming complete ring; seta D2 of abdominal segments approximately ¼ dorsoventral diameter of segment; lingua and gorge of mentum bare (Fig. 11) ................ *disclusa*

– Pinaculum SD1 of 8th abdominal segment with large pale center; pinaculum SD1 of mesothorax forming incomplete ring; seta D2 of abdominal segments approximately ⅓ dorsoventral diameter of segment; lingua and gorge of mentum spinose (Fig. 13) ........... *clarioralis*

5. Perianal region with pale brown tipped spines, spines appearing slender at low magnification; epipharynx with pale, coarse spines at base; hypopharynx with lingua bearing numerous coarse spines (Fig. 14) ................ *amatella*

– Perianal region with dark reddish brown tipped spines, spines appearing stout at low magnification; epipharynx with dark reddish brown tipped coarse spines at base; hypopharynx with lingua bare or bearing at most a few coarse spines (Fig. 15) .................. *taedivorella*

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# A NEW GENUS AND SPECIES OF HISPINAE (COLEOPTERA: CHRYSOMELIDAE) FROM CENTRAL AMERICA

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*Abstract.*—***Fossispa***, new genus, is described from Guatemala, Jamaica, and Mexico; ***F. lutena*** n. sp. is described and designated the type species. A key to the genera of Uroplatini with clavate antennae is presented.

*Key Words:* Chrysomelidae, Hispinae, beetle, Uroplatini

The Neotropical Hispinae are poorly known. The literature consists of scattered species descriptions, faunal lists, and a few biological notes. The last comprehensive works were by Baly (1885) and Weise (1911). Both of these are much out of date due to the large number of species and genera described since their publication.

Specimens of this species were first received from M. A. Ivie as a genus near *Brachycoryna*. A third specimen was later received from S. M. Clark. From a search in the collection at the U.S. National Museum, eight additional specimens were found amoung the unidentified Neotropical Hispinae.

Measurements were taken with an ocular micrometer. The total length is from the anterior margin of the pronotum to the apex of the elytra. Pronotal length is from the base to the apex of the pronotum. Pronotal width is along the midline. Elytral length is from the elytral base to apex. Elytral width was taken at the humeri. In the type designations, a slash (/) separates data on different labels.

## *Fossispa*, New Genus

*Head:* micropunctate; median sulcus present; three short lateral sulci near each eye; antennae inserted into quadrate pit; pit divided by keel; carina around each eye; antenna 8-segmented, clavate. *Pronotum:* wider than long; completely margined at sides; raised areas between punctures micropunctate. *Scutellum:* quadrate; micropunctate. *Elytron:* with four discal costae, 3rd costa short and weak, costae 1, 2, and 4 unite apically; punctures in double rows, with 8 rows of punctures basally, 10 rows apically, basal rows 5 and 6 in longitudinal, median depression, latter rows briefly ex-

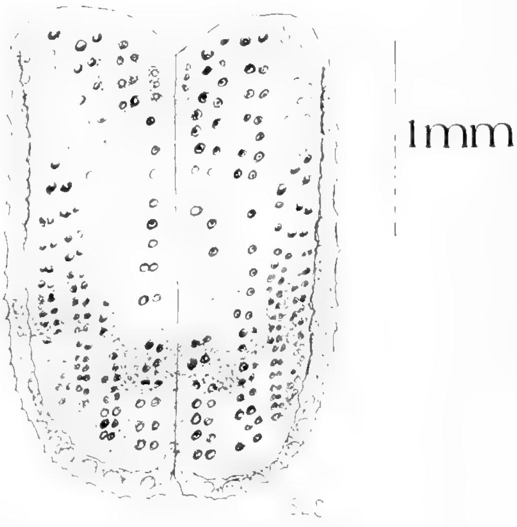

Fig. 1. Elytra of *Fossispa lutena*.

pand to 4 rows behind middle of elytron; a short weak costa between apical rows 6 and 7; costae and raised areas between punctures micropunctate. *Venter:* rugose at sides.

Type species of the genus.—*Fossispa lutena,* new species.

Etymology.—*Fossispa,* fossa = ditch or trench plus ispa, Latin. The gender is neuter.

Comparative notes.—*Fossispa* belongs in the tribe Uroplatini as shown by the 8-segmented antenna. *Fossispa* is most similar to *Heptatomispa* Uhmann. *Fossispa* differs from *Heptatomispa* as follows:

| Character | *Heptatomispa* | *Fossispa* |
|---|---|---|
| vertex of head | not sulcate | sulcate |
| antennae | 7-segmented, segments thick, 1 not much narrower than 7 | 8-segmented; segments 1–6 thin, 7–8 expanded |
| pronotum | highly arched; longitudinal prebasal impression present | not arched; no prebasal impression |
| scutellum | longer than wide | about as long as wide |
| elytra | three entire costae; costa 2 does not unite with 1 & 3 | three entire plus one incomplete costae; costa 2 unites with 1 & 3 |

## KEY TO THE GENERA OF UROPLATINI WITH CLAVATE ANTENNAE

1\. Antenna 7-segmented; last four segments combined not longer than the three preceding combined ........ 2
Antenna 7- or 8-segmented; last four segments combined longer than the three preceding combined ........ 3
2\. Elytral costae irregular, tuberculate ........ *Physocoryna* Guérin
– Elytral costae regular ...... *Corynispa* Uhmann
3\. First 5 antennal segments similar; segment 6 widened; club as long as 4 preceding segments combined; antenna 7-segmented . *Bruchia* Weise
– Antenna not as above ........ 4
4\. Elytral costae irregular, tuberculate ........ 5
– Elytral costae regular ........ 6
5\. Antennal segments 7 and 8 almost fused; segments 1 to 6 thick ......... *Acritispa* Uhmann
– Antennal segments 7 and 8 distinct ........ *Octotoma* Chevrolat (in part)
6\. Third tarsal segment not obviously bilobed ........ *Stenopodius* Horn
– Third tarsal segment obviously bilobed .... 7
7\. Each elytron on apical third with 8 rows of punctures ........ 8
– Each elytron on apical third with 10 rows of punctures ........ 9
8\. Antennal segment 7 as wide as 8 ........ *Octotoma* Chevrolat (in part)
– Antennal segment 7 narrower than 8 ........ *Parvispa* Uhmann
9\. Base of each elytron with 10 rows of punctures ........ *Brachycoryna* Guérin
– Base of each elytron with 8 rows of punctures ........ 10
10\. Expanded puncture rows on apical half of elytra not divided by a costa; vertex of head not sulcate ........ *Heptatomispa* Uhmann
– Expanded puncture rows on apical half of elytra divided by a costa; vertex of head sulcate . *Fossispa* NEW GENUS

## *Fossispa lutena,* NEW SPECIES

*Head:* black; micropunctate; median sulcus present, sometimes weak; occiput concave, with 3 lateral sulci near each eye; antennal pit quadrate, longer than wide; keel sharper anteriorly; carina around each eye; antenna 8-segmented; segments I–VI cylindrical, II widest and longest; VII expanded, ring of setae on middle; VIII expanded, hirsute, rounded at apex; I–III glabrous; IV–VI with some setae; mouthparts ventrally directed. *Pronotum:* wider than long; completely margined at sides; lateral margins parallel at apical ⅔, then convergent; covered with coarse, deep punctures, weaker on disc; raised areas between punctures micropunctate; yellow with variable brown maculae anteriorly and laterally; width 0.9 to

Fig. 2. Distribution of *Fossispa lutena.*

1.3 mm (avg. 1.1) (n = 10); length 0.6 to 0.8 (avg. 0.7). *Scutellum:* brown; quadrate; longer than wide; micropunctate. *Elytron:* (Fig. 1). 8 rows of punctures at base, expands to 10 after middle; scutellar row of 3 punctures; punctures usually in double rows, but may be confused; 3 complete discal costae plus one short, weak costa on apical third, 1, 2, and 4 united on apical fifth; suture costate; elytral base explanate, expanded over base of pronotum; humeral angles strongly produced; raised areas on costae and between punctures micropunctate; margin serrate; apices cojointly rounded; at middle, puncture rows 5 and 6 enter longitudinal depression, expand to two additional rows divided by a weak costa; small depression between puncture rows 3 and 4 on basal third, 3rd interspace weakly costate; 4th costa highly carinate from humerus, the extent of projection variable, up to the lateral or posterior margin, the area between costa and margin recurved; yellow with scattered brown maculae; width 1.3 to 1.7 mm (avg. 1.5); length 2.0 to 2.7 (avg. 2.3). *Legs:* yellow; trochanter brown, angular; femur widest in middle; tibia widest at apex, row of setae on inner side and at apex; each tarsus as follows—segments I and II small, cylindrical, pad of setae beneath; III bilobed, ⅓ length of IV, pad of setae beneath; IV long, widening at apex; claws divergent. *Venter:* black, prosternum punctate in middle, rugose at sides, truncate at apex; mesosternum smooth, shining in middle, rugose at sides; several punctures around coxae; metasternum smooth, shining in middle, rugose at sides; abdominal sterna smooth in middle, rugose at sides, all with scattered setae. *Total length:* 2.6 to 3.4 mm (avg. 3.0).

Type data.—*Holotype:* MEXICO: Vera

Cruz-Tampico, 11/25/72, F. Parker & D. Miller; deposited in the U.S. National Museum. *10 Paratypes:* GUATEMALA: Esquintla Prov., May 14, 1965, E. J. Hambleton/ sweeping ex. *Cymbopogon* spp./ 64–65. JAMAICA: Portland Par., Millbank, 10 August 1987, M. A. Ivie colr.; deposited in the M. A. Ivie collection; St. Ann Parish, Ocho Rios, 19 October 1985, J. A. Suey colr.; deposited in the S. M. Clark collection; St. Catherine Parish—2 miles n. of Guanabon Vale, 6-VI-1975, A. Harkins. MEXICO: Chaiapas-Tempisque, 6/VII/63, Whitehead & Woodruff: Guerrero-Barra Vieja, DCD, 10/X/84, Seguva, Gillett, and Miranda/ on leaf of *Sida* sp., coll. 78/ LPL 1012; Bara Nieja, ACD, 23/I/85, Richardo Sequta, ex. *Sida acuta*/ LP 1490; Barra Vieja, 5/IX/86, Gillett & Miranda/ on *Sida* sp./ LP 889; Barra Vieja, ACA, 10/X/84, Sequta, Gillett, & Miranda/ on leaf of *Sida acuta*/ LPL 1011. Unless otherwise noted the paratypes are deposited in the U.S. National Museum.

*Distribution:* Jamaica, Guatemala, and Mexico (Fig. 2).

Etymology.—the specific ephithet, *lutena* is from the Latin luteus meaning yellow, and refers to the yellow dorsal color of the pronotum and elytra.

Habitat.—adults have been collected from *Sida acuta* Burm. and *Sida* sp. (Malvaceae) leaves and by sweeping *Cymbopogon* spp. (Poaceae).

Immature stages unknown.

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# BIOLOGY OF A PINE NEEDLE SHEATH MIDGE, *CONTARINIA ACUTA* GAGNÉ (DIPTERA: CECIDOMYIIDAE), ON LOBLOLLY PINE

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*Abstract.*—The biology of a pine needle sheath midge, *Contarinia acuta* Gagné is described for a new host in Louisiana. This midge was found feeding within the needle sheath on elongating needles of loblolly pine, *P. taeda* L. Needle droop and partial defoliation were evident on heavily infested trees. Overwintering *C. acuta* adults were first detected emerging from the soil on April 30, 1984. The population progressed through four generations between May 11 and September 17, 1984.

*Key Words:* *Contarinia* sp., pine needle sheath midge, pine seed orchards, loblolly pine

Two species of *Contarinia* are known to cause needle droop on pines in North America. One, the introduced *Contarinia baeri* (Prell), is found on Scots pine, *Pinus sylvestris* L., and on red pine, *P. resinosa* Ait., in northeastern North America. It was first discovered in Europe in 1930 (Skuhravý 1973) and later reported on Scots pine in Canada (DeBoo et al. 1973, Wilson et al. 1988). The second species, *Contarinia acuta* Gagné, is found on slash pine, *P. elliottii* Engelmann, in southeastern United States. Gagné and Beavers (1984) reported on *C. acuta* and three other *Contarinia* species. The last three were recovered from pitfall traps only, so their role on slash pine is unknown.

*Contarinia acuta* was found in 1971 to cause needle droop and defoliation on loblolly pine at the Erambert Seed Orchard in Brooklyn, Mississippi (Overgaard et al. 1976). Populations continued to build until 1975 when the population collapsed (Overgaard et al. 1976). An evaluation conducted from March to September 1975 detected three major larval population peaks: the first peak in May, the second peak beginning in late June, and the third peak beginning in mid-to-late July (Overgaard et al. 1976). Similar damage was reported in 1975 from an orchard in McNair, Mississippi (Overgaard et al. 1976). The next documented report of an outbreak of this species occurred in 1983 at the Stuart Seed Orchard in Pollock, Louisiana (Weatherby et al. 1983). During this outbreak, only loblolly pines were infested, while slash, longleaf, and shortleaf pines remained unaffected. This paper reports on the biology of *C. acuta* infesting loblolly pine in central Louisiana.

## MATERIALS AND METHODS

Larval sampling procedures. Field studies were conducted at the Stuart Seed Orchard. In 1983, actively growing shoots from susceptible clones were sampled. Clones 5, 18, 20, 30, and 43 were selected from clones in the Texas loblolly seed source. One ramet of each clone was randomly selected on August 23. Five shoots of new growth were clipped from each ramet and 25 fascicles were randomly selected from each shoot. The fascicle sheath was removed and the number of larvae per fascicle recorded. On August 31, four different ramets of three of the five original clones were randomly selected and sampled. Five shoots of new growth were selected and five fascicles per shoot were removed for examination from each of the sample ramets. The number of larvae per fascicle was recorded. A final examination was conducted on October 19.

In 1984, sample trees were randomly selected from a 52-acre block of mature loblolly trees grafted from Louisiana seed sources. Larval development was monitored by sampling fascicles from sample branches. After needle elongation began in the spring, two sample branches were removed from the upper portion of the canopy and one sample branch was removed from the middle portion of each sample tree. A total of 12 trees were sampled every 2 weeks from April 13 through August 28. Sample branches from each tree were placed in a plastic bag and transported back to the laboratory. Five fascicles were removed from the last growth flush on each branch, the needle sheaths were removed, and the needles were inspected under a dissecting microscope. The numbers of first instar, second instar, and third instar larvae per fascicle were recorded. During periods when multiple growth flushes and overlapping generations coincided, five fascicles were removed from each of the last two growth flushes on each sample branch. Larval densities were determined for each instar on the last two growth flushes.

Prepupal sampling procedures. Prepupal migration from trees to pupation sites in the soil was monitored with sticky traps. Plywood squares, 0.30 m by 0.30 m, were covered with white freezer paper and sprayed with Tree Tanglefoot (Tanglefoot Company, Grand Rapids, MI). These squares were mounted horizontally on top of 0.91 m stakes. Five sample trees were randomly selected and four traps, one at each cardinal point, were placed under the dripline of each tree. Prepupal traps were installed on May 25 and monitored through September 17, 1984. Traps were inspected weekly and larvae were counted and removed.

Adult sampling procedures. Adult flights were monitored by using adult emergence traps. Traps were constructed from 11.36 l plastic wash tubs and 0.24 l glass jars. The mouth of a jar was inserted into a hole on the side of the tub and secured with a fitting that was attached to the exterior side of each tub approximately 2.54 cm above the bottom. Each tub was inverted and one trap was placed under the dripline of each sample tree. A total of five traps were placed in the Louisiana loblolly seed source. The emergence traps were installed on March 10, 1984, and the jars were inspected weekly for emerging adults. Adult midges were removed from each trap and placed in vials containing 70 percent ethanol. These vials were forwarded to RJG for identification. The traps were relocated after the prepupal migration of each generation in order to capture adults. Adult trapping was terminated on September 17.

## RESULTS AND DISCUSSION

In 1983, the mean larval density on clones 5, 18, 20, 30, and 43 was 14.48 larvae per fascicle on August 23. Populations decreased dramatically by August 31 to 2.51 larvae per fascicle and no larvae were detected on October 19, indicating that the late August generation was the overwintering generation (Table 1).

Population sampling conducted in 1984

Table 1. Comparison of mean larval densities recorded on the last three sampling dates at the U.S. Forest Service Stuart Seed Orchard, Pollock, LA (1983).

| Clone | Mean Number of Larvae per Fascicle<br>Aug. 23 | Aug. 31 | Oct. 19 |
|---|---|---|---|
| 5 | 11.14 | —[a] | — |
| 18 | 17.82 | 2.48 | 0.00 |
| 20 | 17.64 | — | — |
| 30 | 14.09 | 1.43 | 0.00 |
| 43 | 11.72 | 3.61 | 0.00 |
| Mean | 14.48 | 2.51 | 0.00 |

[a] — Indicates that samples were not taken.

Table 2. Means of larval population densities obtained from branch samples taken from loblolly pines in the Louisiana seed source at the U.S. Forest Service Stuart Seed Orchard, Pollock, LA (1984).

| Date | Growth Flush | # Fasc. | Number of Larvae/Fascicle<br>1st Instar $\bar{x}$ | 2nd Instar $\bar{x}$ | 3rd Instar $\bar{x}$ |
|---|---|---|---|---|---|
| April | | | | | |
| 13 | 1st | 225 | 0.00 | 0.00 | 0.00 |
| 30 | 1st | 180 | 0.00 | 0.00 | 0.00 |
| May | | | | | |
| 11 | 1st | 180 | 0.19 | 0.00 | 0.00 |
| 17 | 1st | 750 | 0.11 | 0.19 | 0.11 |
| 31 | 1st | 180 | 0.18 | 0.00 | 0.00 |
| June | | | | | |
| 11 | 1st | 180 | 0.35 | 0.00 | 0.01 |
| | 2nd | 120 | 0.10 | 0.00 | 0.01 |
| 18 | 1st | 180 | 0.25 | 0.29 | 0.11 |
| | 2nd | 145 | 0.03 | 0.04 | 0.02 |
| 26 | 1st | 175 | 0.07 | 0.08 | 0.10 |
| | 2nd | 170 | 0.05 | 0.06 | 0.02 |
| July | | | | | |
| 13 | 2nd | 155 | 0.66 | 0.09 | 0.04 |
| | 3rd | 170 | 1.30 | 0.09 | 0.00 |
| 20 | 2nd | 180 | 0.09 | 0.16 | 0.00 |
| | 3rd | 180 | 0.45 | 0.74 | 0.03 |
| 27 | 3rd | 180 | 0.02 | 0.02 | 0.17 |
| August | | | | | |
| 10 | 3rd | 170 | 0.06 | 0.04 | 0.05 |
| | 4th | 70 | 0.99 | 0.11 | 0.14 |
| 28 | 3rd | 150 | 0.19 | 0.15 | 0.03 |
| | 4th | 15 | 0.93 | 1.27 | 0.07 |

showed that the population progressed through four generations between April 30 and September 17. Adult emergence of the 1983 overwintering generation was detected on April 30 and continued through May 18. The second, third, and fourth adult flights occurred between June 4 and June 18, June 25 and July 18, and August 8 and August 27, respectively.

Adult emergence from overwintering sites, oviposition, and egg hatch of the first generation coincided with the beginning of needle elongation on the first growth flush of the trees in the Louisiana loblolly seed source. During subsequent flight periods, females preferentially oviposited on the most recent foliage. First and second generation larvae primarily infested the first growth flush. Third generation larvae infested both second and third growth flushes. The last or fourth generation larvae were found within the fascicles of the fourth growth flush.

Mean larval densities per fascicle of first, second, and third instars for each sample date are listed in Table 2. These densities were considerably less than those recorded for the final generation in 1983. The presence of first instar larvae were first detected on May 11. Three additional population peaks occurred on June 11, July 13, and August 10. Similar peaks in larval density were detected for second instars. Considerable reduction occurred in the population densities between second and third instars (Table 2). This reduction could have been a real decrease attributed to natural mortality, or it could have been a result of poor synchronization between sampling frequency and phenology of each generation.

Third instar larvae developed to the prepupal stage within the fascicle sheath. Prior to pupation, prepupae left the sheath and fell to the ground. Pupation occurred in the ground litter under the canopy. Peak migrations to the ground of the first, second, and third generation prepupae were detected on May 29, June 27, and August 6 (1984), respectively (Table 3). A fourth generation prepupal peak was barely detectable due to a rapid collapse in the population.

Table 3. Mean number of prepupae captured on 1 sq. ft. sticky traps located under the dripline of loblolly pines in the Louisiana seed source at the U.S. Forest Service Stuart Seed Orchard, Pollock, LA (1984).

| Date | Mean Number of Prepupae per 1 Sq. Ft. | Date | Mean Number of Prepupae per 1 Sq. Ft. |
|---|---|---|---|
| May 29 | 4.10 | July 16 | 0.20 |
| 31 | 0.20 | 18 | 0.00 |
| June 4 | 0.50 | 20 | 0.00 |
| 6 | 0.05 | 25 | 0.10 |
| 8 | 0.05 | 27 | 0.20 |
| 11 | 0.25 | August 3 | 0.15 |
| 13 | 0.00 | 6 | 2.70 |
| 15 | 0.15 | 8 | 0.10 |
| 18 | 0.10 | 10 | 1.40 |
| 20 | 1.00 | 13 | 0.00 |
| 22 | 0.40 | 17 | 0.00 |
| 25 | 1.65 | 22 | 0.00 |
| 27 | 11.25 | 24 | 0.00 |
| 30 | 6.55 | 28 | 0.00 |
| July 2 | 0.40 | September 4 | 0.20 |
| 4 | 0.20 | 6 | 0.05 |
| 6 | 0.30 | 10 | 0.00 |
| 9 | 0.60 | 12 | 0.00 |
| 11 | 0.05 | 17 | 0.00 |
| 13 | 0.15 | | |

During the 1984 outbreak, larval mortality between the second stadium and the prepupal stage of the fourth generation was high. Increasing populations of the natural enemies, particularly *Pyemotes emarginatus* Cross, Moser, and Rack, were observed during larval sampling. Cross, Moser, and Rack (1981) discuss the biology of this mite parasitoid that is known only from *C. acuta*. In addition, several predaceous larvae of *Lestodiplosis* (Cecidomyiidae) were found within the fascicle sheaths with *C. acuta* larvae.

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# *GRYPOTES PUNCTICOLLIS* (HOMOPTERA: CICADELLIDAE), A PALEARCTIC PINE-FEEDING LEAFHOPPER NEW TO NORTH AMERICA

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*Abstract.*—*Grypotes puncticollis* (Herrich-Schaeffer), an Old World deltocephaline leafhopper belonging to the small tribe Grypotini, was recently detected at Erie, Pennsylvania. Nymphs and adults were abundant on Scotch pine, *Pinus sylvestris* L., and Swiss mountain pine, *P. mugo* Turra. Populations also were found on Scotch pine in nearby Crawford Co. and in three western New York counties: Allegany, Cattaraugus, and Chautauqua. It is suggested that *G. puncticollis* is a relatively recently invader in North America and that it was introduced with egg-infested nursery stock. Adult and nymphal characters facilitating recognition of this immigrant in the Nearctic fauna are provided. Two other leafhopper species were collected on Scotch pine during the survey for *G. puncticollis*: *Empoasca perlonga* Davidson & De Long and *Gyponana geminata* (Osborn).

*Key Words:* Auchenorrhyncha, immigrant insect, *Pinus sylvestris, Pinus mugo*

*Grypotes puncticollis* (Herrich-Schaeffer) is a Palearctic deltocephaline leafhopper belonging to the small Old World tribe Grypotini (4 spp.). This pine specialist, common throughout much of continental Europe and England, ranges from Scandinavia south to Spain and northern Africa (Algeria, Tunisia) and east to the European USSR and Turkey (Metcalf 1967). Scotch pine, *Pinus sylvestris* L., Austrian pine, *P. nigra* Arnold, and *P. brutia* have been reported as hosts (Ossiannilsson 1983, Lodos and Kalkandelen 1985 and references therein). This apparently univoltine species overwinters in the egg stage; adults are present from July to October or even early November. In Turkey, *G. puncticollis* has been listed as a pest of *P. brutia* and *P. nigra* (Ossiannilsson 1983, Lodos and Kalkandelen 1985 and references therein). Metcalf's (1967) world catalogue may be consulted for references to additional European literature containing ecological notes.

Herein, *G. puncticollis* is reported as new to the Western Hemisphere. North American locality records are listed and mapped, and characters facilitating its recognition in the Nearctic fauna are provided.

## Distribution and Host Plants

The initial collection of *G. puncticollis* was made on 21 July 1988 on the Mercyhurst College campus, Erie, Pennsylvania, during routine insect collecting on *Pinus sylvestris.* Although I had collected previously on Scotch pine in Pennsylvania (Wheeler and Henry 1973, Wheeler 1987), I was unfamiliar with the brownish-yellow leafhopper found on this conifer at Erie. Fourth and fifth instars were present and adults were abundant on a row of pines. I suspected that this species was an immigrant, but Hamil-

Fig. 1. Known North American distribution of the Palearctic leafhopper *Grypotes puncticollis*. Black dots indicate established populations; counties in which limited surveys for *G. puncticollis* on Scotch pine were negative are represented by open circles (negative sites in Ohio are not shown).

ton (1983) did not include any Scotch pine feeders among Cicadellidae common to the Old and New World and (1985) noted that leafhoppers were not known from this plant in Canada. K. Valley was able to eliminate the unknown Scotch pine cicadellid as conspecific with any listed in Oman (1949) or Beirne's (1956) leafhoppers of Canada and Alaska. With access to European literature and specimens, E. R. Hoebeke determined the species as the Palearctic *G. puncticollis.*

After this immigrant was identified, surveys were made in Pennsylvania, particularly in the northwestern counties, and in western New York and northeastern Ohio to try to delimit its Nearctic range. The first Erie collection was from Scotch pine, and late instars and adults were found later at the same site on dwarf and on upright, shrubby cultivars of Swiss mountain pine, *P. mugo* Turra. For all other collections listed below, *P. sylvestris* was the host; all collections were made by the author in 1988 except for the 13 September collection from Erie, which was made by H. G. Wolff. Specimens have been deposited in the insect collections of Cornell University (CUIC), Ithaca, NY; Pennsylvania Department of Agriculture (PDA), Harrisburg; and U.S. National Museum of Natural History (USNM), Washington, DC.

NEW YORK: *Allegany Co.,* SUNY—Alfred State University, Alfred, 31 July; *Cattaraugus Co.,* Salamanca, 31 July; *Chautauqua Co.,* Fredonia and Jamestown, 31 July. PENNSYLVANIA: *Crawford Co.,* Allegheny College, Meadville, 1 Aug.; *Erie Co.,* Edinboro, 1 Aug.; Mercyhurst College, Erie, 21 July, 1 Aug., 13 Sept.; North East, 1 Aug.

Although *G. puncticollis* was common on Scotch and Swiss mountain pines in Erie Co., Pennsylvania, and present at one of several localities sampled in Crawford Co., it was not collected on pines in several nearby counties or in other areas of the state. Abundant in western New York, it was not taken in limited surveys in other counties or in northeastern Ohio (Fig. 1).

The abundance of this leafhopper near Lake Erie and failure to detect populations elsewhere suggest a limited distribution in North America and a relatively recent introduction. If *G. puncticollis* had been introduced early in the twentieth century before the United States implemented plant quarantine legislation (Wheeler and Nixon 1979, Kim 1983), it probably would be more widespread and have been detected much earlier. If it were now widely distributed on Scotch pine in Ontario and elsewhere in eastern Canada, it probably would not have been overlooked during recent studies of Canadian leafhoppers and been included in Hamilton's (1983) review of holarctic Cicadellidae or in Hamilton and Langor's (1987) report on the fauna of Newfoundland and Cape Breton Island. It seems reasonable to assume that *G. puncticollis* was introduced to the Lake Erie region with European shipments of conifer nursery stock containing its eggs. Opening of the St. Lawrence Seaway to ship traffic in the late 1950's may have been involved in this introduction. The large volume of maritime shipping along this waterway has been implicated in the spread of an immigrant coccinellid, *Coccinella undecimpunctata* L. (Watson 1979).

## RECOGNITION FEATURES

A diverse leafhopper fauna is not characteristic of pines in Pennsylvania. The coelidine *Neocoelidia tuberculata* (Baker) sometimes is common on native pitch pine, *Pinus rigida* Mill., and Virginia pine, *P. virginiana* Mill., and occasionally occurs on cultivated red pine, *P. resinosa* Ait. (personal observation). Few leafhopper species have adapted to introduced pines like *P. sylvestris*; Hamilton (1985) did not list any Canadian species from Scotch pine. A typhlocybine, *Empoasca perlonga* Davidson & De Long, was commonly encountered on Scotch pine in the survey for *G. puncticollis* in New York and Pennsylvania. Hamilton (1985) reported jack pine, *P. banksiana* Lamb., as its host plant. In Pennsylvania, *Gyponana geminata* (Osborn) also was taken on Scotch pine. This gyponine feeds on jack pine in Canada (Hamilton 1985) and is common on pitch pine in Pennsylvania (personal observation).

From these pine-feeding species and other North American leafhoppers, *G. puncticollis* can be separated by the characters given by LeQuesne (1969) and Ossiannilsson (1983): Head distinctly wider than pronotum, ocelli remote from eyes (about equidistant between eye and median line), and anteclypeus narrow and apically bent caudad. North American material generally agrees with descriptions of European specimens. The adult (Fig. 2) is 3.96–4.68 mm long, brownish yellow, and shining with a greyish-green tinge. Among salient features that can be considered diagnostic are face with 3 dark, often fuscous, transverse streaks, the upper 2 arched and faint or interrupted medially and extending laterally to eyes; vertex with sinuate dark streaks between eyes and oblique dark spots or bars from eye toward base; pronotum with dark spots anteriorly; and scutellum with dark transverse suture and usually 2 dark spots anteriorly. Male and female genitalia are illustrated by LeQuesne (1969) and Ossiannilsson (1983); Villiers (1977) provided a color illustration of the adult.

Ossiannilsson (1983) briefly described the last instar nymph as uniformly brownish, with head much wider than the pronotum, and with longer setae only on abdominal tergites VII and VIII. Last instars from Erie, Pennsylvania, have the head broader than pronotum and lack dorsal setae except at apex of abdomen; coloration, however, dif-

Fig. 2. *Grypotes puncticollis*, adult habitus; scale bar = 1.0 mm.

fers from Ossiannilsson's characterization. Nymphs from Pennsylvania range from pale yellow without dorsal markings (perhaps recently molted individuals) to brownish yellow with well-developed dark markings; the midline is pale in all specimens. Some specimens are suffused with pink, the roseate tinge usually restricted to the wingpads and apex of abdomen. Other prominent features are antennae fuscous except basal segments pale; face generally unmarked except for series of faint transverse lines; vertex usually bearing dark markings, sometimes appearing as nearly circular areas on either side of midline; pronotum with dark spots similar to markings of adult or nearly uniformly brown; wingpads generally pale, area between bases of pads darkened; abdomen usually infuscate, ranging from yellow with dark markings to dark brown with scattered pale spots; legs mostly pale, prominent dark spots at base of hind tibial spines.

Specimens examined: 51 adults and 57 fifth instars from Mercyhurst College, Erie, Pennsylvania, 21 July and 1 Aug. 1988, on *Pinus mugo* and *P. sylvestris*; deposited in the collections of CUIC, PDA, and USNM.

## Acknowledgments

I am grateful to K. Valley (BPI, PDA) for identifying *Gyponana geminata*, eliminating any native species as the suspected immigrant leafhopper on *Pinus sylvestris*, and reading the manuscript; E. R. Hoebeke (Dept. of Entomology, Cornell University, Ithaca, NY) for identifying *Grypotes puncticollis* and reading the manuscript; M. R. Wilson [CAB International Institute of Entomology, % British Museum (Natural History), London] for confirming the determination of *G. puncticollis*; K. G. A. Hamilton (Biosystematics Research Centre, Ottawa, Ont.) for identifying *Empoasca perlonga*; H. G. Wolff (BPI, PDA) for making a follow-up collection at Erie; J. F. Stimmel (BPI, PDA) for the photograph used in Fig. 2; T. J. Henry (Systematic Entomology Lab., USDA, % U.S. National Museum of

Natural History, Washington) for reading the manuscript; and M. Lacey (Systematic Entomology Lab., Taxonomic Services Unit, USDA, Beltsville, MD) for sending specimens to the British Museum for confirmation.

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# NEW RECORDS OF PHYCITINAE FROM BOLIVIA INCLUDING A NEW SPECIES OF *PEADUS* (LEPIDOPTERA: PYRALIDAE)

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*Abstract.*—The following species are recorded from Bolivia for the first time: *Hypargyria definitella* (Zeller); *Hypsipyla grandella* (Zeller); *Hemiptilocera chinographella* Ragonot; *Hyalospila clevelandella* (Dyar); *Piesmopoda ragonoti* (Dyar); ***Peadus bolivianus***, new species; *Megarthria beta* Heinrich; ***Stylopalpia fuscifrontella*** (Zeller), new combination; *Adelphia ochripunctella* (Dyar); *Caristanius pellucidellus* (Ragonot); *Eurythmasis ignifatua* Dyar; *Unadilla erronella* (Zeller); *Baphala homoeosomella* (Zeller); *Edulica compedella* (Zeller).

*Key Words:* distribution, new combination, new species

Heinrich in 1956 recorded nine species of Phycitinae from Bolivia based on specimens collected by T. Steinbach in the early 1900's, on loan from the British Museum of Natural History and the Janse Collection. It appears that the phycitines Heinrich studied were only a part of those collected by Steinbach. Recently, through the generosity and assistance of John E. Rawlins, I have had an opportunity to study additional Steinbach phycitines from Bolivia in the Collection of the Carnegie Museum of Natural History (CMNH). In addition to providing a more comprehensive list of the Phycitinae occurring in Bolivia, the study has established the correct generic placement of Zeller's *Nephopteryx* (sic) *fuscifrontella,* and brought to light a new species in the genus *Peadus* Heinrich.

As best I can determine, Steinbach did all of his collecting in east Bolivia. Except for a very few, his collection labels read simply "P. del Sara" or "Prov. del Sara." This refers to a province in east Bolivia presently known as Provincia del Gutiérrez, in the Department of Santa Cruz. In the few instances where specimens were obtained at localities other than Provincia del Gutiérrez, or additional data were placed on the label, this information has been included as an annotation in the following list.

*Hypargyria definitella* (Zeller): Two males and one female; collected in January and December.

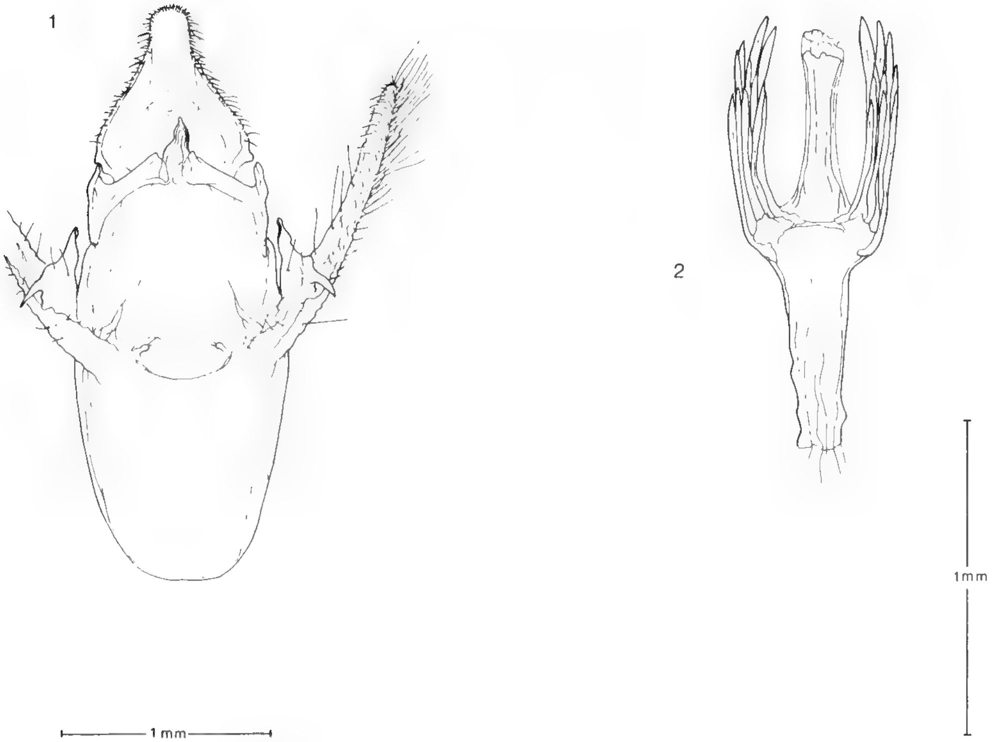
*Hypsipyla grandella* (Zeller): One female; collected in July; 450 m.

*Hemiptilocera chinographella* Ragonot: Two males and one female; collected in January, August and November; 450 m. One female; collected in July; Sta. Cruz de la Sierra [Dept. Santa Cruz], 450 m. One female; collected in December; Puerto Suarez [Dept. Santa Cruz] 150 m.

*Hyalospila clevelandella* (Dyar): Two males; collected in December.

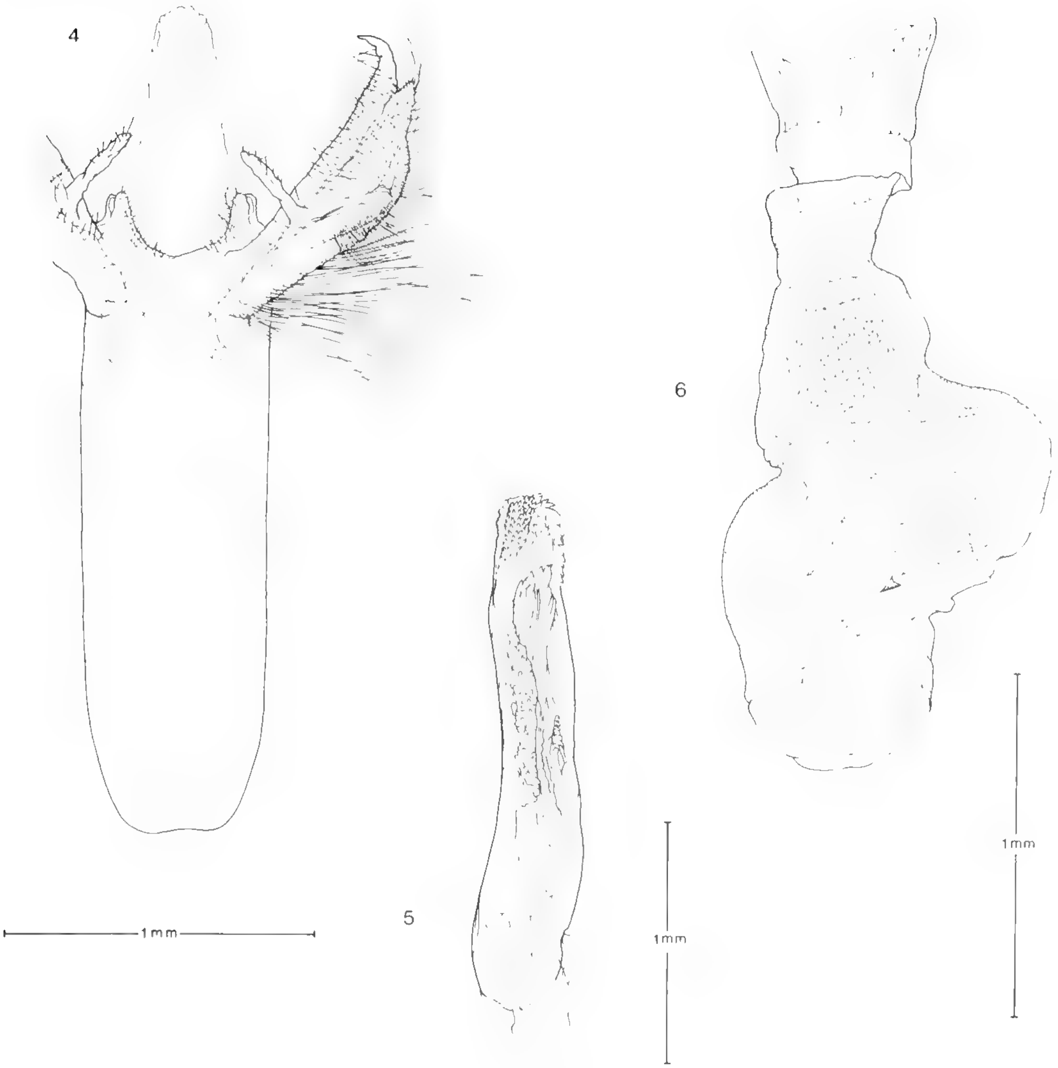
*Piesmopoda ragonoti* (Dyar): One male; [no collection date].

*Megarthria beta* Heinrich: One female; collected in January. Heinrich (1956) was not able to associate males and females within the genus *Megarthria.* The few females that he studied and considered to be-



Figs. 1–2. *Stylopalpia fuscifrontella.* 1, male genitalia, most of left valva and aedeagus omitted. 2, aedeagus.

Fig. 3. *Peadus bolivianus,* holotype.



Figs. 4–6. *Peadus bolivianus.* 4, Male genitalia, most of left valva and aedeagus omitted. 5, aedeagus. 6, female genitalia.

long to two species within the genus were simply named by him, *alpha* and *beta.* Apparently based on similar distributions, Heinrich suggested that *alpha* was possibly the female of *Megarthria peterseni* (Zeller). It now appears equally possible that *beta* is the female of *peterseni* because the present study has demonstrated that *beta* also occurs in South America in the same general area where *peterseni* is found.

*Stylopalpia fuscifrontella* (Zeller), **New Combination**: Two males and twelve females; collected in January, March, April, November, December. Zeller in 1881 treated *fuscifrontella* as a *Nephopterix.* Heinrich (1956) examined females of the species and concluded that *fuscifrontella* did not belong to *Nephopterix,* but he was unable to establish its correct generic placement because he had no males available for study. My examination of the male genitalia of specimens collected by Steinbach (Figs. 1, 2) clearly shows the species to be a member of *Stylopalpia* Hampson. The small valva, the presence of a strongly sclerotized, large clasper near the inner base of the valva, and the lateral flanges of the aedeagus with their clusters of large spines are particularly characteristic for the genus.

*Adelphia ochripunctella* (Dyar): One female; collected in November. *A. ochripunctella* has previously only been reported from San Diego, California (Heinrich, 1956). Nevertheless, based on the characteristic wing markings and genitalia of the species, there is no doubt that the species also occurs in Bolivia.

*Caristanius pellucidellus* (Ragonot): One female; collected in November.

*Eurythmasis ignifatua* Dyar: Two males and one female; collected in January, November and December.

*Unadilla erronella* (Zeller): One male; collected in December.

*Baphala homoeosomella* (Zeller): One male; collected in December; 450 m.

*Edulica compedella* (Zeller): One female; collected in August; Buena Vista [Dept. Santa Cruz]; 400 m.

### ***Peadus bolivianus*** **Neunzig, New Species**

Figs. 3–6

Description.—*Head:* Pale-golden-brown suffused with reddish brown or with reddish brown and fuscous. Labial palpus reaching slightly above vertex (longer in female than male), pale golden-brown suffused with reddish brown and fuscous; 3rd segment darker than other segments. Maxillary palpus squamous, pale golden brown. Male antenna with elongate basal tuft of dark, appressed scales; sensilla trichodea (cilia) of shaft near base about as long as width of basal segments of shaft. *Collar:* Pale golden brown dorsally, with small lateral patch of reddish brown or reddish brown and fuscous. *Forewing:* Pale golden yellow above dusted with white in costal half, particularly near costa; costal half also with a few reddish brown scales interspersed with white scales, and solid reddish brown patches, sometimes with fuscous, at costa; antemedial line absent; discal spots reddish brown; postmedial line white or very pale golden brown, moderately distinct; patch of reddish brown and fuscous scales preceding postmedial line; terminal margin with row of dark scales; undersurface without contrasting sex-scales. Length of wing 8.0–8.5 mm. *Hindwing:* Pale smoky brown basally, dark brown along termen. *Male genitalia* (Figs. 4, 5): Uncus and tegumen greatly reduced; gnathos not defined; valva appearing partially divided longitudinally with inner subbasal digitate element and costal half strongly recurved distally; vinculum long, almost 3× as long as its greatest width; aedeagus spined at apex and with cornutus consisting of a cluster of small spines. *Female genitalia* (Fig. 6): ductus bursae short, posterior half with numerous microspines; corpus bursae with numerous microspines in posterior two-thirds; signum small, short, thornlike.

*P. bolivianus* is easily separated from other species in *Peadus* on the basis of the very elongate vinculum of the male genitalia of *bolivianus* and the more abundant, and more generally distributed, microspines in the corpus bursae of the female genitalia of *bolivianus.*

Type material.—Holotype: ♂; Bolivia: Prov. del Sara, Nov. 1913, Steinbach: genitalia slide HHN 2373: in CMNH. Paratypes: 1 ♂, 1 ♀; same location and collector, Dec. 1911: genitalia slides HHN 2374, 2388a: in CMNH.

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# A NEW SPECIES OF NEOTROPICAL WATER BUG, *PARAVELIA BIAE*, FROM BRAZIL (HETEROPTERA: VELIIDAE)

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*Abstract.*—A new species of veliid water bug, ***Paravelia biae***, from Pará, Brazil, is described and compared with the species *Paravelia platensis* Berg and *Paravelia williamsi* Hungerford, which it resembles; distinguishing characters are illustrated by line drawings and scanning electron micrographs. The habitat is discussed and illustrated.

*Key Words:* Heteroptera, Veliidae, Brazil, *Paravelia biae* n. sp.

In 1986, several biologists from the Smithsonian Institution participated in a survey of the fauna of an area on the Xingu River about 60 km south of Altamira, Pará, Brazil, that is scheduled for impoundment following the construction of a large hydroelectric dam on the river. The attractive water-strider described below was collected during the survey.

### ***Paravelia biae*** **Spangler, New Species**

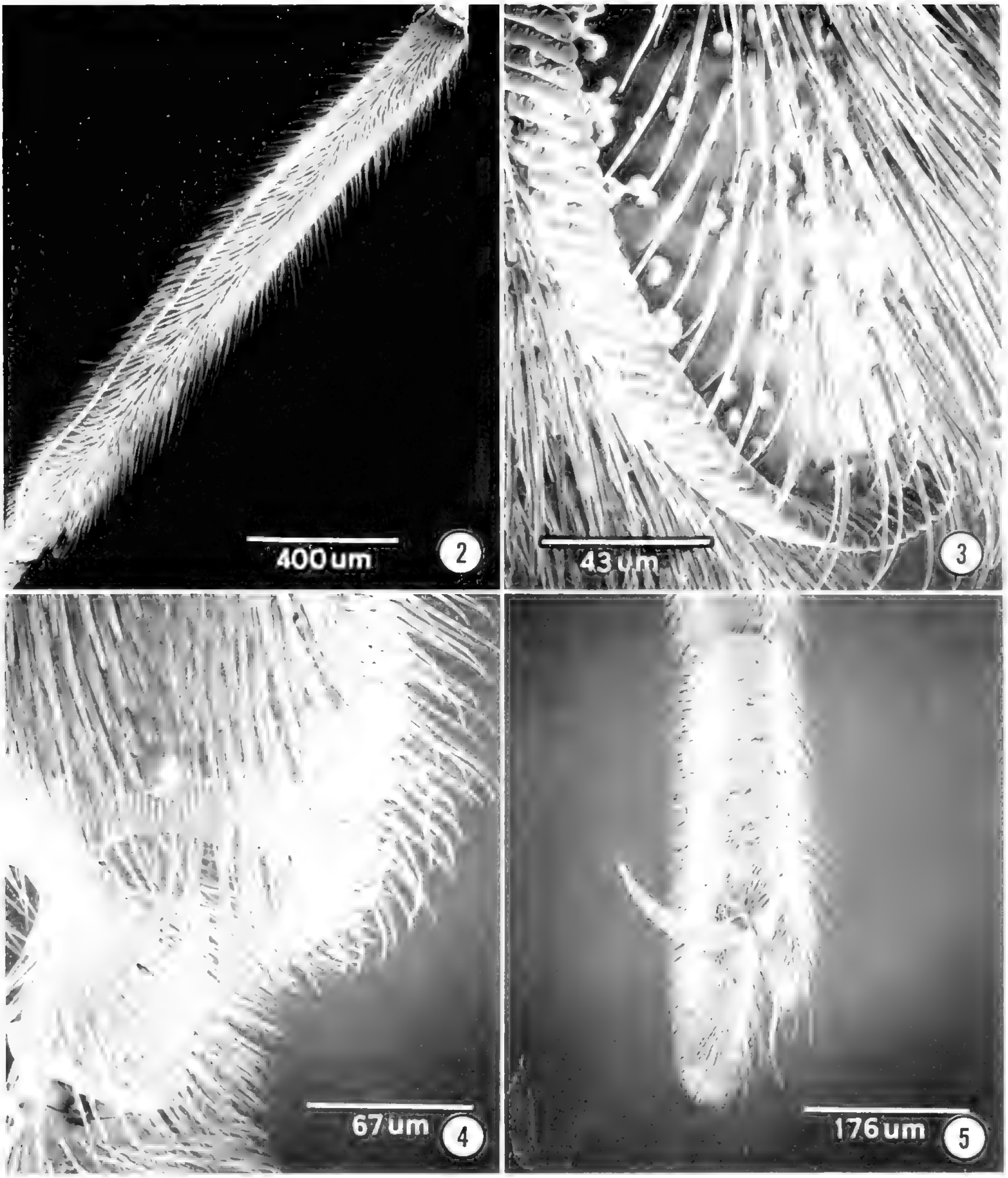
Figs. 1–8, 15, 16

Macropterous holotype male (Fig. 1).—*Size:* Length, 6.45 mm; greatest width, 2.50 mm.

*Color:* Black except coxae and base of rostrum slightly reddish brown and each hemelytron with a bright yellow macula near base and another, oval in shape, on membranous apex; therefore, with wings in normal position over abdomen, 3 yellow maculae readily visible. Cuticle covered with dense yellowish-brown pubescence.

*Head:* Width between eyes, 0.50 mm. Cuticle finely pubescent; with sparse, long, slender, black setae among shorter, dense,

Fig. 1. *Paravelia biae*, male, habitus view, ×14.



Figs. 2–5. *Paravelia biae*, male: 2, Protibial grasping comb, ×70. 3, Distal end of protibial grasping comb, ×450. 4, Protibial grasping comb and grooming comb, ×700. 5, Protarsal claws, ×170.

reddish-brown setae. Rostrum extending to anterior margin of mesocoxal cavities. Antennae with fine, dense, reddish-brown to yellowish pubescence and a few longer, darker setae interspersed; segment 1 arcuate, narrowest at base then distinctly swollen and parallel sided on distal four-fifths, distinctly thicker and a fifth longer than segment 2; segment 2 more slender and slightly longer than segment 3; segment 4 more slender and about a fifth longer than segment 3.

*Thorax:* Pronotum narrowest apically, sides diverging, moderately arcuate, strongly gibbose laterally slightly before midlength; lateral margins behind gibbose area broadly rimmed; with low median longitudinal carina on meson; terminating in a moderately long, robust, finger-like process projecting posteriad. Cuticle with 2 sparse, coarsely punctate, transverse rows on anterior seventh; disc with most coarse punctures separated by 4 to 5 times their diameter; also with an oblique row of coarse, distinct punctures laterad of procoxae. Protibia with distal grasping comb extending about three-fourths length of tibia (Figs. 2–4) and grooming comb on apex (Fig. 4). Protarsal claws slender (Fig. 5).

*Abdomen:* Cuticle with fine, dense, short, yellowish pubescence intermixed with sparser, longer setae. Laterotergites moderately reflexed above abdominal terga. Segment 7 (sixth visible) with a strong angular gibbosity on each side of meson along posterior margin of segment; ovate genital capsule twice as long as segment 7 on midline.

*Genitalia:* Proctiger with posterior half pubescent and heavily sclerotized at basodorsal angle (Fig. 6). Clasper sinuate; with cluster of setae basally and a row of evenly spaced, erect stiff setae on upper margin (Fig. 8).

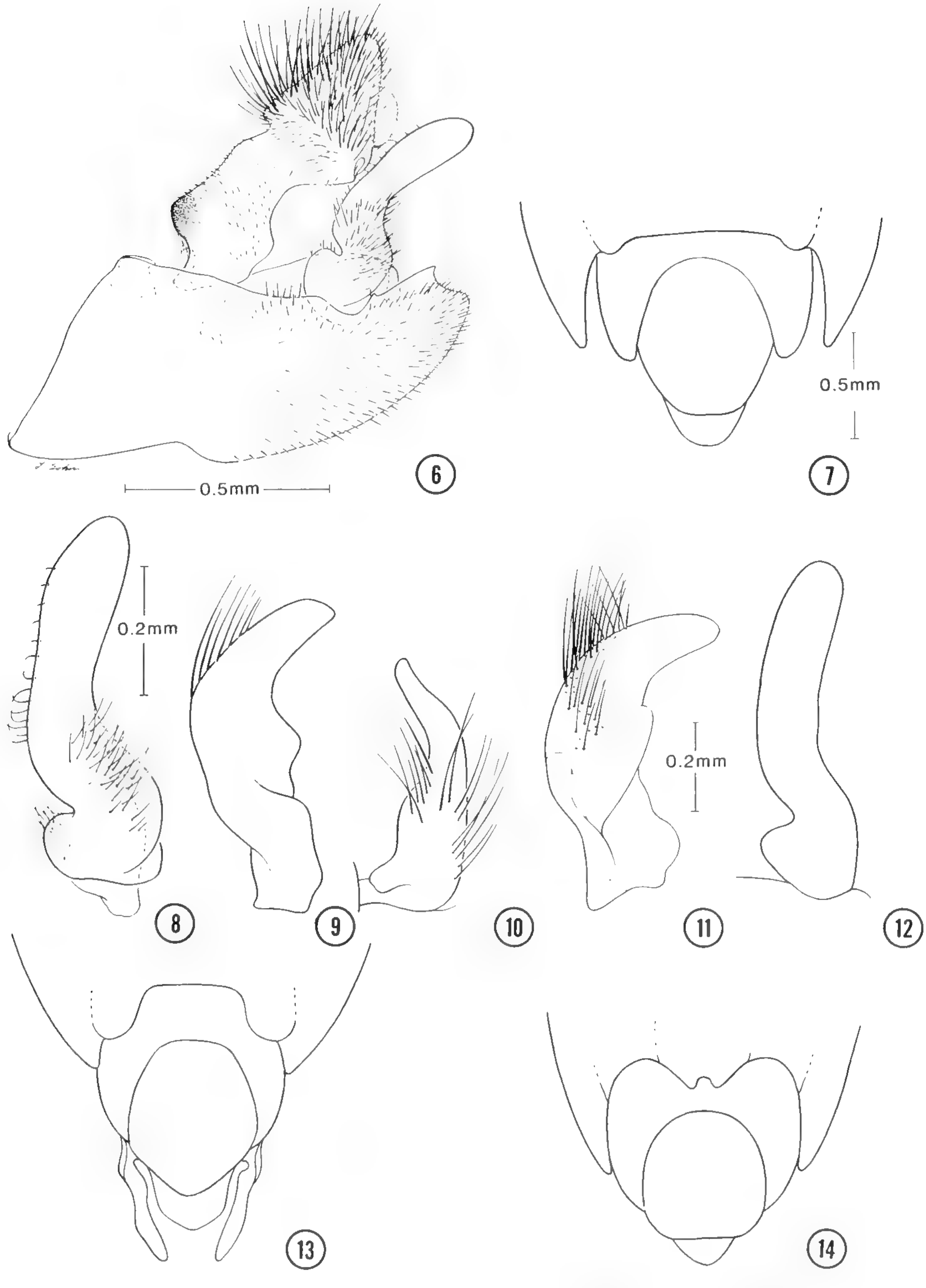
Female.—Similar to male but lacks angular gibbosities on posterior margin of abdominal segment 7 and genital capsule is replaced by an extensible ovipositor.

Comparative notes.—*Paravelia biae* is most similar to *Paravelia platensis* Berg, 1883, and *Paravelia williamsi* Hungerford, 1930, but differs from both by being black instead of chocolate brown, by the low pronotal carina extending from collar to base where it ends in a finger-like lobe, and by its more robust body that is thicker dorsoventrally. In addition, males of *P. biae* have a gibbosity on each side of the meson of sternum 7 that are separated by a very broad and shallow apicomedial emargination (Fig. 7) in contrast to males of *P. platensis* that have a broad longitudinal keel on the meson of sternum 7 (Fig. 14) and males of *P. williamsi* that have a gibbosity on each side of the meson of sternum 7 that are separated by a broad and deep apicomedial emargination (Fig. 13).

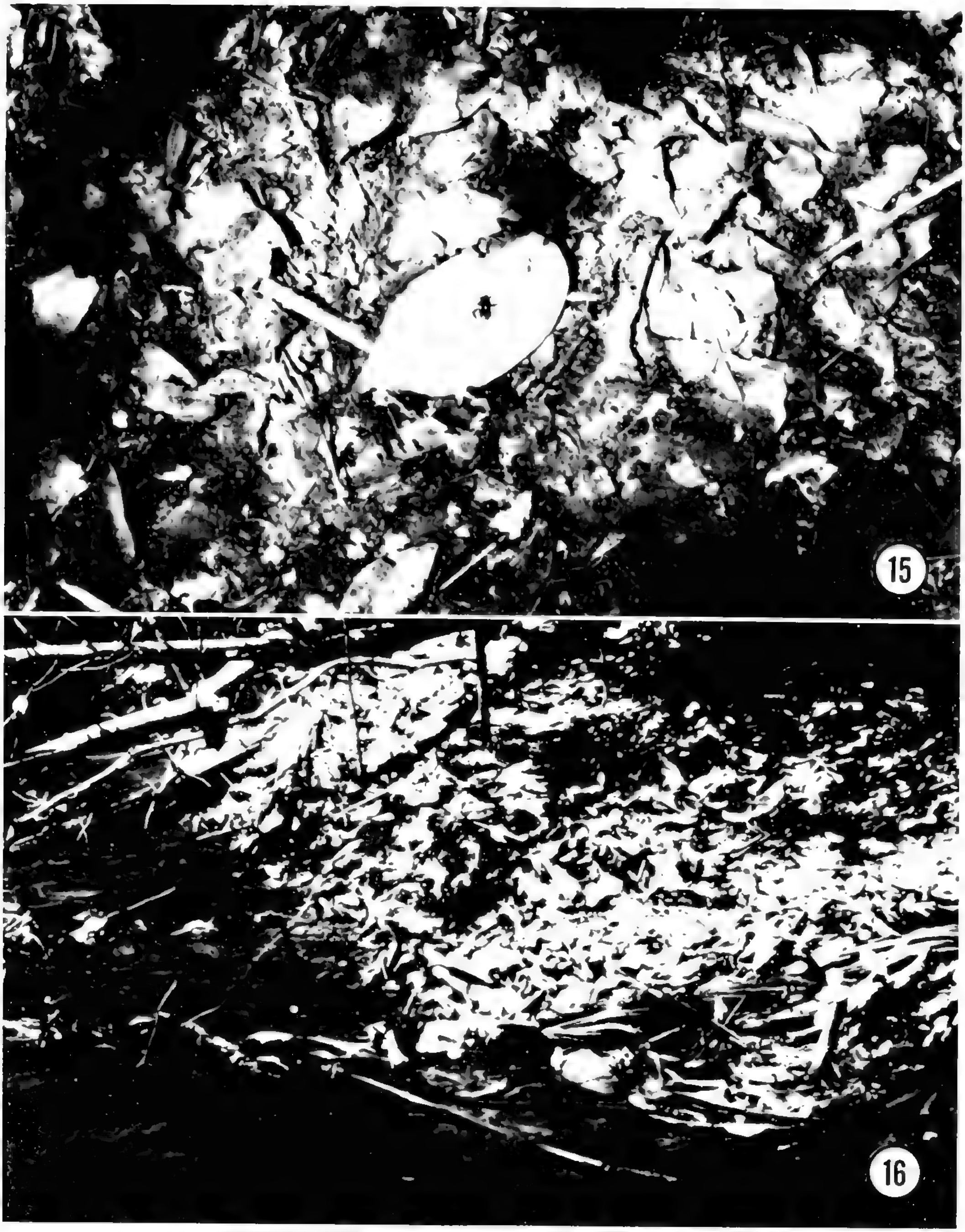
The male claspers of the known species of *Paravelia* are distinctive and the obvious differences between the right (Fig. 9) and left clasper (Fig. 10) in Hungerford's (1930) illustrations of *P. platensis* seemed odd. Both claspers of specimens of *P. biae* and all other species of *Paravelia* that I have examined are symmetrical. The illustration of asymmetrical claspers included by Hungerford suggested that one of the two claspers of his specimen of *P. platensis* is aberrant. Although Hungerford did not mention that, he may have had the same suspicion and, by luck or design, he included figures of both claspers. By dissecting and clearing the genital capsule of a male *P. platensis* in the Drake Collection in the National Museum of Natural History, I found that the claspers are symmetrical as illustrated in Figure 11 and closely approximate Hungerford's figure of the right clasper (Fig. 9). Therefore, I believe his figure of the left clasper (Fig. 10) illustrates an aberrant one.

Type data.—Macropterous holotype male and allotype: BRAZIL: PARÁ: Altamira (60 km S), 52°22′W, 3°39′S, 10 Oct 1986, 1st stream, trail 4, coll'n #19, P. Spangler & O. Flint; deposited in the Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil.

*Paratypes:* Same data as holotype, 147 ♂, 267 ♀; same locality and data except: 13 Oct 1986, 5 ♂, 14 ♀; 19 Oct. 1986, in flight intercept trap, 1 ♂, 2 ♀; 21 Oct. 1986, in flight intercept trap, 1 ♂, 1 ♀. BRAZIL: PARÁ: Itaituba: São Lonis, 15.3.41, leg. H. Sioli, S16, 1 ♂, 1 ♀. Paratypes will be deposited in the Museu de Zoologia, Universidade de São Paulo, São Paulo; the American Museum of Natural History, New York, New



Figs. 6–14. 6–8, *Paravelia biae,* male genitalia: 6, genital capsule, lateral view; 7, abdominal venter; 8, left clasper. 9–11, *Paravelia platensis,* male genitalia: 9, right clasper; 10, left clasper; 11, left clasper (specimen in Drake Collection). 12–13, *Paravelia williamsi*: 12, left clasper; 13, abdominal venter. 14, *Paravelia platensis,* abdominal venter. Figures 9, 10, 12, 13, 14—after Hungerford, 1930.



Figs. 15–16. *Paravelia biae*: 15, exposed after overturning leaves. 16, biotope; 60 km south of Altamira, Pará, Brazil.

York; the British Museum (Natural History), London; the California Academy of Sciences, San Francisco, California; the Canadian National Collection, Ottawa; Institut Royal de Histoire naturelles de Belgique, Bruxelles; Instituto de Zoologia Agricola, Facultad de Agronomia, Universidad Central Venezuela, Maracay; Laboratorium voor Zoologische, Oecologie en Taxonomie, Utrecht; the Muséum National de Histoire Naturelle, Paris; Museo Argentino de Ciencias Naturales, Buenos Aires; Universidad Nacional de La Plata y Museo, La Plata; the National Museum of Natural History, Smithsonian Institution, Washington, D.C.; the Snow Entomological Museum, University of Kansas, Lawrence, Kansas; Zoologische Staatssammlung, München (Sioli's specimens); and the collection of John T. Polhemus, Englewood, Colorado.

Etymology.—This species is named *biae* for Maria Beatriz (Bia) Riviero do Vallé, conservationist and our kind and efficient host.

Habitat.—Most of the specimens of this new species were collected from a small stream in the lowland tropical forest near our base camp. The stream was about 1.5–2 m wide and about 15–45 cm deep for much of its course as it meandered and flowed slowly through the forest. The stream was mostly shaded throughout the day but the collection site of this veliid was exposed to sunlight for about an hour at noontime. The first few specimens were observed on the water at the shoreline (Fig. 16). When attempts were made to net them, they ran onto the leaf-covered bank where the leaves had to be brushed aside to find them (Fig. 15). In so doing, I was surprised to find them so abundant under the leaves that many crawled back under the leaves faster than they could be picked up. I quickly obtained 220 specimens within an area of approximately 2 square meters. All specimens were found no farther than 1.25 meters from the water's edge. Additional collecting in the 10 meters downstream, where the bank was shaded, yielded some specimens but distinctly fewer than I found in the sunny area.

Following a heavy rain about a week after the first collections were made, I found 5 specimens of this veliid alive on the rainwater and greatly diluted ethylene glycol in a yellow plastic trough under a flight intercept trap operating about a half kilometer from the stream; evidently the bugs flew from the stream and were captured by the trap. Presumably, the veliid's behavior of moving about on the surface film kept them from drowning as other insects did when they flew into the intercept trap panel and fell into the trough.

Possibly, when the heavy rains begin after the dry season, as happened during this fieldwork, the veliids disperse from areas of dense population to new habitats with less competition for food.

It is also of interest to note that all specimens collected were winged adults. Perhaps breeding begins after the onset of the rainy season when new habitats become available and the presumed dispersal of the adults occurs.

## ACKNOWLEDGMENTS

For making the fieldwork possible, I thank the following: the Consórcio Nacional de Engenheiros Consultores S.A. (CENEC) for financial support; Paulo Vanzolini, who kindly arranged for our participation in the project; and Maria Beatriz (Bia) Ribeiro do Valle, whose efficient logistical arrangements made the trip so enjoyable.

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Hungerford, H. B. 1930. Three new *Velia* from South America. J. Kans. Entomol. Soc. 3: 23–27.

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# NEEM (*AZADIRACHTA INDICA* A. JUSS): ORGANISMS AFFECTED AND REFERENCE LIST UPDATE

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*Abstract.*—A compilation of neem literature for the last decade is presented that updates a review by Warthen 1979. The compilation includes literature citations and tables that list organisms affected by neem as well as activities and compounds.

*Key Words:* Neem, *Azadirachta indica, Melia azadirachta, M. indica,* Meliaceae, Margosa tree, Indian lilac

In 1979, Warthen published a review of the neem literature that was entitled "*Azadirachta indica*: A Source of Insect Feeding Inhibitors and Growth Regulators." The review was very popular worldwide with scientists inolved in neem research as well as with others who were either interested in neem or in the utilization of neem for insect pest control.

During the last decade, the number of neem publications has increased greatly. Since 1979, three international neem conferences have been held; proceedings (Schmutterer et al. 1980, Schmutterer and Ascher 1983, 1987) of these meetings and attendance have increased with each subsequent conference.

During this time period, Vikwood Ltd. formulated a neem seed extract (Margosan-O), for which EPA approval was granted for use on ornamental plants. Presently, W. R. Grace & Co. and Vikwood Ltd. are working cooperatively to market this product and to gain EPA approval for its utilization on edible plants as well.

Worldwide interest has been generated by neem as attested to in the 194 new citations in the last decade within this compilation. The National Research Council, Office of International Affairs, recognizing this interest and the utilization potential for third world countries, called a meeting in April 1988 to consider the possibility of publishing a book on neem for the National Academy of Sciences.

Organisms affected by neem are listed in Table 1; the entries, addressed mainly to entomologists, are alphabetized by Phylum, Class, Order, Family, Genus, Species, and then Literature Citation. Activities, Compounds, and Literature Citations of neem, without reference to organisms affected, are listed in Table 2; entries are alphabetized by first author of the Literature Citation.

This compilation is not an exhaustive search of the literature for the last decade; many pre-1979 literature citations appear, and others (Warthen 1979, Schmutterer et al. 1980, Schmutterer 1981, Schmutterer and Ascher 1983, 1987, Olkowski 1987, and Jacobson 1988) should be consulted for further information and other references.

The compilation updates the review by Warthen (1979) and lists organisms in three Phyla, Molusca being new, that are affected by neem along with 277 (194 new) literature

Table 1. Organisms (family, genus, and species) affected by neem; activities, compounds, and literature citations.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Phylum Arthropoda, | Class Acari: | | | |
| Tetranychidae | *Panonychus citri* (McGregor) | | | (Chiu 1982) |
| | Class Insecta | Order Coleoptera | | |
| Bostrichidae | *Rhyzopertha dominica* (F.) | antifeedant | | (Anonymous) |
| Bostrichidae | *Rhyzopertha dominica* (F.) | deterrent | | (Devi and Mohandas 1982) |
| Bostrichidae | *Rhyzopertha dominica* (F.) | protectant | | (Pereira and Wohlgemuth 1982) |
| Bostrichidae | *Rhyzopertha dominica* (F.) | | | (Qadri and Rao 1977) |
| Bruchidae | *Callosobruchus analis* (F.) | growth regulator | isonimolicinolide | (Siddiqui et al. 1987) |
| Bruchidae | *Callosobruchus analis* (F.) | growth regulator | nimolicinoic acid | (Siddiqui et al. 1987) |
| Bruchidae | *Callosobruchus chinensis* (Lucas) | larval toxicant | plant oils | (Ali et al. 1984) |
| Bruchidae | *Callosobruchus maculatus* (F.) | antifeedant | | (Anonymous) |
| Bruchidae | *Callosobruchus maculatus* (F.) | | alkanes | (Ivbijaro 1983a) |
| Bruchidae | *Callosobruchus maculatus* (F.) | protectant | | (Jotwani and Sircar 1967) |
| Bruchidae | *Callosobruchus maculatus* (F.) | protectant | | (Pereira 1983) |
| Chrysomelidae | *Acalymma vittatum* (F.) | antifeedant | | (Reed et al. 1981) |
| Chrysomelidae | *Acalymma vittatum* (F.) | feeding deterrent | azadirachtin | (Reed et al. 1982) |
| Chrysomelidae | *Acalymma vittatum* (F.) | feeding deterrent | salannin | (Reed et al. 1982) |
| Chrysomelidae | *Aulacophora foveicollis* (Lucas) | repellent | thionimone | (Chakravorty et al. 1969) |
| Chrysomelidae | *Aulacophora foveicollis* (Lucas) | repellent | | (Pradhan et al. 1963) |
| Chrysomelidae | *Aulacophora foveicollis* (Lucas) | deterrent | | (Pradhan and Jotwani 1968) |
| Chrysomelidae | *Aulacophora foveicollis* (Lucas) | antifeedant | | (Pradhan and Jotwani 1971a) |
| Chrysomelidae | *Aulacophora foveicollis* (Lucas) | antifeedant | | (Pradhan and Jotwani 1971b) |
| Chrysomelidae | *Diabrotica undecimpunctata howardi* Barber | antifeedant | | (Reed et al. 1981) |
| Chrysomelidae | *Diabrotica undecimpunctata howardi* Barber | feeding deterrent | azadirachtin | (Reed et al. 1982) |
| Chrysomelidae | *Diabrotica undecimpunctata howardi* Barber | feeding deterrent | salannin | (Reed et al. 1982) |
| Chrysomelidae | *Galleria mellonella* (L.) | deterrent | azadirachtin | (Zanno et al. 1975) |
| Chrysomelidae | *Leptinotarsa decemlineata* (Say) | antifeedant | | (Steets 1976) |
| Chrysomelidae | *Leptinotarsa decemlineata* (Say) | feeding inhibitor | | (Zehnder and Warthen 1988) |
| Chrysomelidae | *Leptinotarsa decemlineata* (Say) | toxicant | | (Zehnder and Warthen 1988) |
| Chrysomelidae | *Phyllotreta striolata* (F.) | | azadirachtin | (Meisner and Mitchell 1982) |
| Chrysomelidae | *Podagrica uniformis* (Jacoby) | repellent | azadirachtin | (Redknap 1979) |
| Coccinellidae | *Epilachna varivestis* Mulsant | hot tasting | | (Ascher and Gsell 1981) |
| Coccinellidae | *Epilachna varivestis* Mulsant | deterrent | 1,3-diacetylvilasinin | (Kraus et al. 1980) |
| Coccinellidae | *Epilachna varivestis* Mulsant | deterrent | 3-desacetylsalannin | (Kraus et al. 1980) |
| Coccinellidae | *Epilachna varivestis* Mulsant | deterrent | salannol | (Kraus et al. 1980) |

Table 1. Continued.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Coccinellidae | *Epilachna varivestis* Mulsant | synergist | S421 | (Lange and Schmutterer 1982) |
| Coccinellidae | *Epilachna varivestis* Mulsant | synergist | sesoxane | (Lange and Schmutterer 1982) |
| Coccinellidae | *Epilachna varivestis* Mulsant | synergist | tropital | (Lange and Schmutterer 1982) |
| Coccinellidae | *Epilachna varivestis* Mulsant | growth disruptant | | (Rembold et al. 1980) |
| Coccinellidae | *Epilachna varivestis* Mulsant | growth regulator | azadirachtin | (Rembold et al. 1982) |
| Coccinellidae | *Epilachna varivestis* Mulsant | | azadirachtin | (Schlüter 1984) |
| Coccinellidae | *Epilachna varivestis* Mulsant | molt inhibitor | azadirachtin | (Schlüter 1985) |
| Coccinellidae | *Epilachna varivestis* Mulsant | growth disruptant | azadirachtin | (Schmutterer and Rembold 1980) |
| Coccinellidae | *Epilachna varivestis* Mulsant | antifeedant | | (Steets 1975) |
| Coccinellidae | *Epilachna varivestis* Mulsant | longevity | azadirachtin | (Steets and Schmutterer 1975) |
| Coccinellidae | *Epilachna varivestis* Mulsant | reproduction | azadirachtin | (Steets and Schmutterer 1975) |
| Cucujidae | *Cryptolestes ferrugineus* (Stephens) | protectant | | (Pereira and Wohlgemuth 1982) |
| Curculionidae | *Sitophilus oryzae* (L.) | antifeedant | | (Anonymous) |
| Curculionidae | *Sitophilus oryzae* (L.) | toxicant | azadirachtin | (Ivbijaro 1983b) |
| Curculionidae | *Sitophilus oryzae* (L.) | protectant | | (Pereira and Wohlgemuth 1982) |
| Dermestidae | *Trogoderma granarium* Everts | antifeedant | | (Anonymous) |
| Scarabaeidae | *Anomala cupripes* Hope | | | (Chiu 1982) |
| Scarabaeidae | *Holotrichia consanguinea* (Blanchard) | attractant | | (Gupta 1973) |
| Scarabaeidae | *Holotrichia insularis* Brenske | attractant | | (Gupta 1973) |
| Scarabaeidae | *Holotrichia insularis* Brenske | | | (Sachan and Pal 1974) |
| Scarabaeidae | *Holotrichia serrata* F. | attractant | | (Gupta 1973) |
| Scarabaeidae | *Popillia japonica* Newman | deterrent | | (Ladd et al. 1978) |
| Scarabaeidae | *Popillia japonica* Newman | growth inhibitor | | (Ladd et al. 1978) |
| Scarabaeidae | *Popillia japonica* Newman | deterrent | | (Ladd et al. 1978) |
| Scarabaeidae | *Popillia japonica* Newman | growth | azadirachtin | (Ladd et al. 1984) |
| Scarabaeidae | *Popillia japonica* Newman | growth regulator | azadirachtin | (Ladd et al. 1984) |
| Scarabaeidae | *Popillia japonica* Newman | | | (Parke 1982) |
| Tenebrionidae | *Tenebrio molitar* L. | growth regulator | azadirachtin | (Redfern et al. 1984a) |
| Tenebrionidae | *Tribolium castaneum* (Herbst) | antifeedant | | (Anonymous) |
| Tenebrionidae | *Tribolium castaneum* (Herbst) | repellent | | (Jilani and Su 1984) |
| Tenebrionidae | *Tribolium castaneum* (Herbst) | repellent | Margosan-O | (Jilani et al. 1988) |
| Tenebrionidae | *Tribolium castaneum* (Herbst) | growth inhibitor | Margosan-O | (Jilani et al. 1988) |
| | | Order Diptera | | |
| Agromyzidae | *Liriomyza sativae* Blanchard | systemic | | (Larew et al. 1984) |
| Agromyzidae | *Liriomyza sativae* Blanchard | | | (Webb et al. 1983) |

Table 1. Continued.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Agromyzidae | *Liriomyza sativae* Blanchard | systemic | azadirachtin | (Webb et al. 1984) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | biocontrol | | (Fagoonee and Toory 1983) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | insecticide | Margosan-O | (Knodel-Montz et al. 1985) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | systemic | | (Larew et al. 1984) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | | | (Larew et al. 1985a) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | repellent | | (Larew et al. 1985b) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | insecticide | | (Larew et al. 1985b) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | toxicant | | (Larew et al. 1985c) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | | | (Webb et al. 1983) |
| Agromyzidae | *Liriomyza trifolii* (Burgess) | systemic | azadirachtin | (Webb et al. 1984) |
| Calliphoridae | *Lucilia cuprina* (Wiedemann) | antifeedant | azadirachtin | (Rice et al. 1985) |
| Calliphoridae | *Lucilia cuprina* (Wiedemann) | ovipositional | azadirachtin | (Rice et al. 1985) |
| Cecidomyiidae | *Orseolia oryzae* (Wood-Mason) | repellent | | (Chiu et al. 1985) |
| Cecidomyiidae | *Orseolia oryzae* (Wood-Mason) | deterrent | | (Chiu et al. 1985) |
| Culicidae | *Aedes aegypti* (L.) | insecticide | azadirachtin | (Zebitz 1984) |
| Culicidae | *Aedes aegypti* (L.) | | azadirachtin | (Zebitz 1986) |
| Culicidae | *Aedes togoi* (Theobald) | | azadirachtin | (Zebitz 1986) |
| Culicidae | *Anopheles stephensi* Liston | | azadirachtin | (Zebitz 1986) |
| Culicidae | *Culex quinquefasciatus* Say | | azadirachtin | (Zebitz 1986) |
| Muscidae | *Musca autumnalis* De Geer | molting inhibitor | azadirachtin | (Gaaboub and Hayes 1984) |
| Muscidae | *Musca domestica* L. | | | (Qadri and Rao 1977) |
| Muscidae | *Musca domestica* L. | feeding deterrent | salannin | (Warthen et al. 1978b) |
| Tephritidae | *Ceratitis capitata* (Wiedemann) | | | (Steffens and Schmutterer 1982) |
| | | Order Heteroptera | | |
| Lygaeidae | *Oncopeltus fasciatus* (Dallas) | nutrition | azadirachtin | (Karnavar 1987) |
| Lygaeidae | *Oncopeltus fasciatus* (Dallas) | reproduction | azadirachtin | (Karnavar 1987) |
| Lygaeidae | *Oncopeltus fasciatus* (Dallas) | molting inhibitor | azadirachtin | (Redfern et al. 1979) |
| Lygaeidae | *Oncopeltus fasciatus* (Dallas) | antifeedant | azadirachtin | (Redfern et al. 1980) |
| Lygaeidae | *Oncopeltus fasciatus* (Dallas) | growth disruptor | azadirachtin | (Redfern et al. 1980) |
| Lygaeidae | *Oncopeltus fasciatus* (Dallas) | growth | azadirachtin | (Redfern et al. 1984a) |
| Miridae | *Piesma quadratum* (Fieber) | | | (Steets 1975) |
| Pyrrhocoridae | *Dysdercus cingulatus* F. | antifeedant | | (Abraham and Ambika 1979) |
| Pyrrhocoridae | *Dysdercus cingulatus* F. | deterrent | | (Abraham and Ambika 1979) |
| Pyrrhocoridae | *Dysdercus cingulatus* F. | insecticidal | | (Abraham and Ambika 1979) |
| Pyrrhocoridae | *Dysdercus fasciatus* Sign. | deterrent | | (Ruscoe 1972) |

Table 1. Continued.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Pyrrhocoridae | *Dysdercus fasciatus* Sign. | growth disruptor | | (Ruscoe 1972) |
| Pyrrhocoridae | *Dysdercus fasciatus* Sign. | repellent | | (Ruscoe 1972) |
| Pyrrhocoridae | *Dysdercus koenigii* (F.) | | azadirachtin | (Koul 1984a) |
| Pyrrhocoridae | *Dysdercus koenigii* (F.) | antifeedant | azadirachtin | (Koul 1984b) |
| Reduviidae | *Rhodnius prolixus* Stål | antifeedant | azadirachtin | (Garcia and Rembold 1984) |
| Reduviidae | *Rhodnius prolixus* Stål | molting inhibitor | 7-acetyl-azadirachtin(a) | (Garcia et al. 1984) |
| Reduviidae | *Rhodnius prolixus* Stål | antifeedant | azadirachtin | (Garcia et al. 1984) |
| | | Order Homoptera | | |
| Aleyrodidae | *Bemisia tabaci* (Gennadius) | deterrent | | (Coudriet et al. 1985) |
| Aleyrodidae | *Bemisia tabaci* (Gennadius) | toxicant | | (Coudriet et al. 1985) |
| Aphididae | *Myzus persicae* (Sulzer) | repellent | | (Griffiths et al. 1978) |
| Aphididae | *Rhopalosiphum nymphaeae* (L.) | deterrent | | (Goyal et al. 1971) |
| Cicadellidae | *Nephotettix virescens* (Distant) | growth disruptor | | (Heyde et al. 1985) |
| Cicadellidae | *Nephotettix virescens* (Distant) | virus transmission | | (Mariappan et al. 1982) |
| Delphacidae | | reduced survival | | (Saxena and Khan 1985) |
| Delphacidae | *Nilaparvata lugens* (Stål) | | | (Chiu 1982) |
| Delphacidae | *Nilaparvata lugens* (Stål) | | | (Saxena et al. 1984) |
| Delphacidae | *Nilaparvata lugens* (Stål) | antifeedant | azadirachtin | (Shinfoon 1985) |
| | | Order Hymenoptera | | |
| Apidae | *Apis mellifera* L. | | | (Rembold et al. 1980) |
| Apidae | *Apis mellifera* L. | antifeedant | azadirachtin | (Rembold and Czoppelt 1981) |
| Apidae | *Apis mellifera* L. | growth regulator | azadirachtin | (Rembold and Czoppelt 1981) |
| Apidae | *Apis mellifera* L. | growth regulator | azadirachtin | (Rembold et al. 1982) |
| Apidae | *Apis mellifera* L. | | | (Sharma et al. 1980) |
| Tenthredinidae | *Fenusa pusilla* (Lepeletier) | insecticide | | (Larew et al. 1987) |
| | | Order Lepidoptera | | |
| Arctiidae | *Amsacta moorei* Butler | deterrent | | (Patel et al. 1968) |
| Gelechiidae | *Pectinophora gossypiella* (Saunders) | biosynthesis | azadirachtin | (Kubo and Klocke 1982) |
| Gelechiidae | *Sitotroga cerealella* (Olivier) | antifeedant | | (Anonymous) |
| Gelechiidae | *Sitotroga cerealella* (Olivier) | antifeedant | brestan | (Asari and Dale 1977) |
| Gelechiidae | *Sitotroga cerealella* (Olivier) | antifeedant | | (Devi and Mohandas 1982) |
| Gelechiidae | *Sitotroga cerealella* (Olivier) | protectant | | (Pereira and Wohlgemuth 1982) |
| Geometridae | *Ascotis selenaria* (Denis and Schiffermüller) | residual effect | | (Meisner et al. 1976) |
| Gracillariidae | *Phyllocnistis citrella* Stainton | | | (Chiu 1982) |

Table 1. Continued.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Lymantriidae | *Euproctis lunata* Walker | deterrent | | (Babu and Beri 1969) |
| Lymantriidae | *Euproctis lunata* Walker | repellent | | (Pradhan et al. 1963) |
| Lymantriidae | *Euproctis lunata* Walker | deterrent | | (Pradhan and Jotwani 1968) |
| Lymantriidae | *Euproctis lunata* Walker | | | (Pradhan and Jotwani 1971a) |
| Lymantriidae | *Euproctis lunata* Walker | | | (Pradhan and Jotwani 1971b) |
| Lymantriidae | *Lymantria dispar* (L.) | | | (Skatulla and Meisner 1975) |
| Noctuidae | *Achaea janata* (L.) | insect control | | (Chari and Muralidharan 1985) |
| Noctuidae | *Ariathisa (Spodoptera) abyssina* (Guenée) | | | (Chiu 1982) |
| Noctuidae | *Earias vittella* (Sabricius) | oviposition | | (Pathak and Krishna 1986) |
| Noctuidae | *Earias vittella* (Sabricius) | egg hatchability | | (Pathak and Krishna 1986) |
| Noctuidae | *Earias insulana* (Boisduval) | feeding deterrent | azadirachtin | (Meisner et al. 1981) |
| Noctuidae | *Earias insulana* (Boisduval) | feeding deterrent | salannin | (Meisner et al. 1981) |
| Noctuidae | *Heliothis virescens* (F.) | biosynthesis | azadirachtin | (Kubo and Klocke 1982) |
| Noctuidae | *Heliothis virescens* (F.) | insecticide | | (Lee et al. 1985) |
| Noctuidae | *Heliothis virescens* (F.) | deterrent | | (Ruscoe 1972) |
| Noctuidae | *Heliothis virescens* (F.) | growth disruptor | | (Ruscoe 1972) |
| Noctuidae | *Heliothis virescens* (F.) | repellent | | (Ruscoe 1972) |
| Noctuidae | *Heliothis virescens* (F.) | deterrent | | (Zanno et al. 1975) |
| Noctuidae | *Heliothis zea* (Boddie) | ecdysis inhibitor | azadirachtin | (Kubo and Klocke 1982) |
| Noctuidae | *Heliothis zea* (Boddie) | biosynthesis | azadirachtin | (Kubo and Klocke 1982) |
| Noctuidae | *Leucania venalba* Moore | | | (Chiu 1982) |
| Noctuidae | *Mamestra brassicae* (L.) | spermiogenetic | azadirachtin | (Shimizu 1988) |
| Noctuidae | *Mamestra brassicae* (L.) | spermiogenetic | Margosan-O | (Shimizu 1988) |
| Noctuidae | *Pseudaletia separata* (Walker) | morphogenetic | | (Schmutterer et al. 1983) |
| Noctuidae | *Sesamia calamistis* Hampson | antifeedant | | (Ho 1983) |
| Noctuidae | *Spodoptera eridania* (Cramer) | antifeedant | limonoids | (Lidert et al. 1985) |
| Noctuidae | *Spodoptera eridania* (Cramer) | antifeedant | azadirachtin | (Lidert et al. 1985) |
| Noctuidae | *Spodoptera exigua* (Hübner) | toxicant | avermectin | (Moar and Trumble 1987) |
| Noctuidae | *Spodoptera exigua* (Hübner) | toxicant | *Bacillus thuringiensis* | (Moar and Trumble 1987) |
| Noctuidae | *Spodoptera exigua* (Hübner) | | | (Prabhaker et al. 1986) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | biosynthesis | azadirachtin | (Kubo and Klocke 1982) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | insecticide | | (Lee et al. 1985) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | feeding deterrent | azadirachtin | (Raffa 1987) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | antifeedant | azadirachtin | (Redfern et al. 1980) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | growth disruptor | azadirachtin | (Redfern et al. 1980) |

Table 1. Continued.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | antifeedant | | (Redfern et al. 1984b) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | antifeedant | | (Stokes et al. 1983a) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | antifeedant | | (Stokes et al. 1983b) |
| Noctuidae | *Spodoptera frugiperda* (J. E. Smith) | antifeedant | azadirachtin | (Warthen et al. 1978a) |
| Noctuidae | *Spodoptera littoralis* (Boisduval) | antifeedant | | (El-Sayed 1985) |
| Noctuidae | *Spodoptera littoralis* (Boisduval) | repellent | | (El-Sayed 1985) |
| Noctuidae | *Spodoptera littoralis* (Boisduval) | feeding deterrent | azadirachtin | (Meisner et al. 1981) |
| Noctuidae | *Spodoptera littoralis* (Boisduval) | antifeedant | salannin | (Meisner et al. 1981) |
| Noctuidae | *Spodoptera littoralis* (Boisduval) | growth regulator | | (Meisner and Ascher 1983) |
| Noctuidae | *Spodoptera littoralis* (Boisduval) | | punic acid | (Meisner et al. 1983) |
| Noctuidae | *Spodoptera litura* (F.) | | | (Chiu 1982) |
| Noctuidae | *Spodoptera litura* (F.) | juvenile hormone | azadirachtin | (Gujar and Mehrotra 1983) |
| Noctuidae | *Spodoptera litura* (F.) | antifeedant | | (Joshi and Ramaprasad 1975) |
| Noctuidae | *Spodoptera litura* (F.) | deterrent | | (Joshi et al. 1978) |
| Noctuidae | *Spodoptera litura* (F.) | repellent | | (Pradhan et al. 1963) |
| Noctuidae | *Spodoptera litura* (F.) | deterrent | | (Pradhan and Jotwani 1968) |
| Noctuidae | *Spodoptera litura* (F.) | | | (Pradhan and Jotwani 1971a) |
| Noctuidae | *Spodoptera litura* (F.) | | | (Pradhan and Jotwani 1971b) |
| Noctuidae | *Trichoplusia ni* (Hübner) | growth regulator | | (Prabhaker et al. 1986) |
| Papilionidae | *Papilio demoleus* (L.) | repellent | azadirachtin | (Redknap 1979) |
| Pieridae | *Pieris brassicae* (L.) | deterrent | | (Ruscoe 1972) |
| Pieridae | *Pieris brassicae* (L.) | growth disruptor | | (Ruscoe 1972) |
| Pieridae | *Pieris brassicae* (L.) | repellent | | (Ruscoe 1972) |
| Pieridae | *Pieris brassicae* (L.) | deterrent | | (Zanno et al. 1975) |
| Pieridae | *Pieris rapae* (L.) | | | (Chiu 1982) |
| Pyralidae | *Antigastra catalaunalis* Duponchel | deterrent | | (Chadha 1977) |
| Pyralidae | *Cnaphalocrocis medinalis* (Guenée) | morphogenetic | | (Schmutterer et al. 1983) |
| Pyralidae | *Crocidolomia binotalis* Zeller | | | (Fagoonee and Lange 1981) |
| Pyralidae | *Ephestia cautella* (Walker) | protectant | | (Pereira and Wohlgemuth 1982) |
| Pyralidae | *Ephestia kuehniella* Zeller | growth disruptor | | (Rembold et al. 1980) |
| Pyralidae | *Ephestia kuehniella* Zeller | growth regulator | azadirachtin | (Rembold et al. 1982) |
| Pyralidae | *Ephestia kuehniella* Zeller | | | (Sharma et al. 1980) |
| Pyralidae | *Maliarpha separatella* Ragonot | antifeedant | | (Ho 1983) |
| Pyralidae | *Ostrinia furnacalis* Guenée | growth disruptor | azadirachtin | (Shinfoon et al. 1985) |
| Pyralidae | *Ostrinia nubilalis* (Hübner) | antifeedant | azadirachtin | (Arnason et al. 1985) |
| Pyralidae | *Ostrinia nubilalis* (Hübner) | insecticide | azadirachtin | (Arnason et al. 1985) |

Table 1. Continued.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Sphingidae | *Manduca sexta* (L.) | ecdysteroid titre | azadirachtin | (Pener et al. 1988) |
| Sphingidae | *Manduca sexta* (L.) | growth regulator | azadirachtin | (Schlüter et al. 1985) |
| Yponomeutidae | *Plutella maculipennis* Curtis | | | (Steets 1975) |
| Yponomeutidae | *Plutella xylostella* (L.) | | | (Adhikary 1985) |
| Yponomeutidae | *Plutella xylostella* (L.) | synergist | piperonyl butoxide | (Lange and Schmutterer 1982) |
| Yponomeutidae | *Plutella xylostella* (L.) | deterrent | | (Ruscoe 1972) |
| Yponomeutidae | *Plutella xylostella* (L.) | growth disruptor | | (Ruscoe 1972) |
| Yponomeutidae | *Plutella xylostella* (L.) | repellent | | (Ruscoe 1972) |
| Yponomeutidae | *Plutella xylostella* (L.) | antifeedant | | (Tan and Sudderuddin 1978) |
| | | Order Orthoptera | | |
| | cockroaches | toxicant | | (Anonymous 1986) |
| Acrididae | *Locusta* | nutrition | azadirachtin | (Karnavar 1987) |
| Acrididae | *Locusta* | reproduction | azadirachtin | (Karnavar 1987) |
| Acrididae | *Locusta migratoria* (L.) | deterrent | | (Pradhan and Jotwani 1968) |
| Acrididae | *Locusta migratoria* (L.) | | | (Pradhan and Jotwani 1971a) |
| Acrididae | *Locusta migratoria* (L.) | | | (Pradhan and Jotwani 1971b) |
| Acrididae | *Locusta migratoria* (L.) | molt inhibitor | azadirachtin | (Rembold et al. 1983) |
| Acrididae | *Locusta migratoria* (L.) | growth regulator | azadirachtin | (Rembold et al. 1983) |
| Acrididae | *Locusta migratoria* (L.) | sexual behavior | azadirachtin | (Shalom and Pener 1984) |
| Acrididae | *Locusta migratoria* (L.) | juvenile hormone | azadirachtin | (Shalom and Pener 1984) |
| Acrididae | *Locusta migratoria* (L.) | pest control | | (Sinha and Gulati 1963) |
| Acrididae | *Schistocerca gregaria* Forskàl | deterrent | | (Attri 1977) |
| Acrididae | *Schistocerca gregaria* Forskàl | deterrent | azadirachtin | (Butterworth and Morgan 1968) |
| Acrididae | *Schistocerca gregaria* Forskàl | deterrent | azadirachtin | (Butterworth and Morgan 1971) |
| Acrididae | *Schistocerca gregaria* Forskàl | deterrent | azadirachtin | (Gill and Lewis 1971) |
| Acrididae | *Schistocerca gregaria* Forskàl | systemic | azadirachtin | (Gill and Lewis 1971) |
| Acrididae | *Schistocerca gregaria* Forskàl | deterrent | | (Goyal et al. 1971) |
| Acrididae | *Schistocerca gregaria* Forskàl | antifeedant | meliantriol | (Lavie et al. 1967) |
| Acrididae | *Schistocerca gregaria* Forskàl | repellent | | (Pradhan et al. 1963) |
| Acrididae | *Schistocerca gregaria* Forskàl | deterrent | | (Pradhan and Jotwani 1968) |
| Acrididae | *Schistocerca gregaria* Forskàl | | | (Pradhan and Jotwani 1971a) |
| Acrididae | *Schistocerca gregaria* Forskàl | | | (Pradhan and Jotwani 1971b) |
| Acrididae | *Schistocerca gregaria* Forskàl | egg hatchability | | (Singh and Singh 1987) |
| Acrididae | *Schistocerca gregaria* Forskàl | pest control | | (Sinha and Gulati 1963) |
| Blattidae | *Periplaneta americana* (L.) | plant pesticides | azadirachtin | (Qadri and Ahmed 1979) |

Table 1. Continued.

| Family | Genus and Species | Activity | Compound | Literature Citations |
|---|---|---|---|---|
| Blattidae | *Periplaneta americana* (L.) | molting effect | azadirachtin | (Qadri and Narsaiah 1978) |
| Gryllidae | *Acheta domesticus* (L.) | antifeedant | azadirachtin | (Warthen and Uebel 1980) |
| Gryllidae | *Acheta domesticus* (L.) | molting disruptor | azadirachtin | (Warthen and Uebel 1980) |
| Pyrgomorphidae | *Poecilocerus pictus* F. | deterrent | | (Pradhan and Jotwani 1968) |
| Pyrgomorphidae | *Poecilocerus pictus* F. | | | (Pradhan and Jotwani 1971a) |
| Pyrgomorphidae | *Poecilocerus pictus* F. | | | (Pradhan and Jotwani 1971b) |
| Pyrgomorphidae | *Poecilocerus pictus* F. | repellent | | (Pradhan et al. 1963) |
| Phylum Mollusca, | Class Gastropoda: | Order Stylommatophora | | |
| Prosobranchia | *Melania scabra* | snail control | | (Muley 1978) |
| Phylum Nematoda: | | | | |
| | *Pratylenchus brachyurus*[1] | maize yield | | (Egunjobi and Afolami 1976) |
| | *Rotylenchulus reniformis*[2] | control | | (Verma and Prasad 1970) |
| Miscellaneous | | | | |
| | albino rats | toxicant | | (Qadri et al. 1984) |
| | arthropods | antifeedant | | (Freeman and Andow 1983) |
| | cotton boll worms | insecticide | | (Thangavel et al. 1975) |
| | crop pests | | | (Anonymous 1979a) |
| | fowl-pox virus | antiviral | | (Rai and Sethi 1972) |
| | fungi nematodes | | | (Khan et al. 1974) |
| | gregarious locust hoppers | unpalatable | | (Batra 1980) |
| | leaf miners | toxicant | | (Anonymous 1986) |
| | mosquitoes | insecticidal | alkanes | (Chavan 1983) |
| | mosquitoes | larvicidal | alkanes | (Chavan 1983) |
| | North American grasshoppers | | azadirachtin | (Mulkern 1971) |
| | potato virus X | antiviral | | (Singh 1971) |
| | shield bug | | | (Leuschner 1972) |
| | stored product insects | | | (Girish and Jain 1974) |
| | stored product insects | repellent | | (Jilani and Malik 1973) |
| | stored product insects | insecticide | | (Jotwani and Srivastava 1981) |
| | stored product insects | repellent | | (Qadri 1973) |
| | vaccinia virus | antiviral | | (Rai and Sethi 1972) |
| | wheat pests | | | (Jotwani and Sircar 1965) |

[1] (Godfrey, 1929) Filipjev & Schuurmans Stekhoven, 1941.
[2] Linford & Oliveira, 1940.

Table 2. Activities, compounds, and literature citations of neem without reference to insects.

| Activity | Compound | Literature Citation |
|---|---|---|
| pyrethrin stabilizer | neem | (Ahmed et al. 1976) |
| miscella refining | neem oil | (Ahuja et al. 1976) |
| | | (Anonymous 1977) |
| | | (Anonymous 1979b) |
| | | (Anonymous 1980) |
| | azadirachtin | (Anonymous 1981) |
| | | (Anonymous 1982a) |
| | limonoids | (Anonymous 1982b) |
| | azadirachtin | (Anonymous 1982b) |
| | azadirachtin | (Anonymous 1985a) |
| deterrent | | (Anonymous 1985b) |
| pharmaceutical | | (Arigrabu and Don-Pedro 1971) |
| | | (Aschenbach 1982) |
| | kaempferol | (Basak and Chakraborty 1968) |
| | nimbin | (Basak and Chakraborty 1968) |
| | quercetin | (Basak and Chakraborty 1968) |
| | $\beta$-sitoserol | (Basak and Chakraborty 1968) |
| | azadirachtin | (Bilton et al. 1985) |
| antifeedant | azadirachtin | (Bilton et al. 1987) |
| antifeedant | azadirachtin | (Broughton et al. 1985) |
| | tetranortiterpenoid | (Bruhn et al. 1984) |
| feeding inhibitor | azadirachtin | (Butterworth et al. 1972) |
| | azadirachtin | (Chadha 1986) |
| | | (Chiu 1983) |
| | meldenin | (Connolly et al. 1968) |
| | | (Doria 1981) |
| repellent | azadirachtin | (Duke 1983) |
| | nimbolide | (Ekong 1967) |
| | gedunin | (Ekong et al. 1969) |
| | nimbolin b | (Ekong et al. 1969) |
| | nimbolin a | (Ekong et al. 1969) |
| biosynthesis | nimbolide | (Ekong et al. 1971) |
| crop protection | | (Fagoonee 1979) |
| | azadirachtin | (Forster 1983) |
| | meliacin | (Garg and Bhakuni 1984a) |
| | tetranortriterpenoid | (Garg and Bhakuni 1984a) |
| | salannolide | (Garg and Bhakuni 1984b) |
| | tetranortriterpenoid | (Garg and Bhakuni 1984b) |
| | nimbraflavone | (Garg and Bhakuni 1984c) |
| feeding inhibitor | | (Gilbert 1982) |
| | nimbin | (Harris et al. 1968) |
| leaf development | | (Harzal 1977) |
| antifeedant | azadirachtin | (Helson 1984) |
| | nimbin | (Henderson et al. 1963) |
| | salannin | (Henderson et al. 1964) |
| | salannin | (Henderson et al. 1968) |
| | | (Hoddy 1985) |
| | | (Jacobson 1980) |
| | | (Jacobson et al. 1983) |
| natural resistance | | (Jacobson 1986) |
| | | (Jain 1983) |

Table 2. Continued.

| Activity | Compound | Literature Citation |
|---|---|---|
| general uses | | (Ketkar 1976) |
| | | (Ketkar 1979) |
| | 17-β-hydroxyazadiradion | (Kraus and Cramer 1978) |
| | epi-azadiradion | (Kraus and Cramer 1978) |
| antifeedant | 1,3-diacetylvilasinin | (Kraus and Cramer 1981) |
| antifeedant | 3-deacetylsalannin | (Kraus and Cramer 1981) |
| antifeedant | salannol | (Kraus and Cramer 1981) |
| | tetranortriterpenoids | (Kraus et al. 1981) |
| antifeedant | meliacin | (Kraus 1983) |
| | azadirachtin | (Kraus et al. 1985) |
| | azadirachtin | (Kraus 1986) |
| | azadirachtin | (Kubo 1979) |
| control agent | azadirachtin | (Kubo and Klocke 1981) |
| antifeedant | deacetylazadirachtinol | (Kubo et al. 1984) |
| | piperonyl butoxide | (Lange and Feuerhake 1984) |
| insecticide | | (Larew 1985) |
| systemic | neem toxin | (Larew 1988) |
| | tetranortripterpenoids | (Lavie and Jain 1967) |
| | azadiradione | (Lavie et al. 1971) |
| | azadirone | (Lavie et al. 1971) |
| | epoxyazadiradione | (Lavie et al. 1971) |
| | gedunin | (Lavie et al. 1971) |
| | tetranortriterpenoids | (Madhusudanan et al. 1984) |
| antifeedant | azadirachtin | (Malik and Naqvi 1984) |
| repellent | azadirachtin | (Malik and Naqvi 1984) |
| repellent | azadirachtin | (Mansour and Ascher 1983) |
| | chemicals | (Mitra et al. 1947) |
| | nimbin | (Mitra 1957) |
| | constituents | (Mitra 1963) |
| | nimbidic acid | (Mitra et al. 1970) |
| | nimbidinin | (Mitra et al. 1970) |
| | nimbidic acid | (Mitra et al. 1971) |
| | nimbidinin | (Mitra et al. 1971) |
| feeding inhibitor | azadirachtin | (Morgan and Thornton 1973) |
| antifeedant | azadirachtin | (Nakanishi 1975) |
| | nimbin | (Narasimhan 1959) |
| | nimbin | (Narayanan et al. 1962) |
| | nimbin | (Narayanan et al. 1964a) |
| | nimbin | (Narayanan et al. 1964b) |
| | nimbin | (Narayanan et al. 1964c) |
| | nimbin | (Narayanan and Pachapurkar 1965) |
| | nimbinic acid | (Narayanan and Pachapurkar 1966) |
| | nimbinin | (Narayanan et al. 1967) |
| | vepinin | (Narayanan et al. 1969) |
| | polysaccharide | (Nayak et al. 1978) |
| | | (Olkowski 1978) |
| | vilasinin | (Pachapurkar and Kornule 1974) |
| general uses | | (Parmar 1984a) |
| general uses | | (Parmar 1984b) |
| general uses | | (Parmar 1985a) |

Table 2. Continued.

| Activity | Compound | Literature Citation |
|---|---|---|
| nitrogen fixing | | (Parmar 1985b) |
| | | (Parmar 1985c) |
| | | (Parmar 1985d) |
| | chemical constituents | (Peterson 1983) |
| antifeedant | azadirachtin | (Pickett 1985) |
| antinuclear study | nimbidin | (Pillai and Santhakumari 1984) |
| deterrent | | (Pradhan et al. 1962) |
| | | (Quasim and Dutia 1970) |
| | | (Radwanski 1977a) |
| general uses | | (Radwanski 1977b) |
| general uses | | (Radwanski 1977c) |
| | | (Radwanski 1977d) |
| | | (Radwanski and Wickens 1981) |
| | tiglic acid | (Raman and Santhanagopalan 1978) |
| growth regulator | azadirachtin | (Rembold 1984) |
| antifeedant | vepaol | (Sankaran et al. 1984) |
| | azadirachtin | (Schroeder and Nakanishi 1987) |
| repellent | azadirachtin | (Schwinger 1982) |
| repellent | warburganal | (Schwinger 1982) |
| spermicide | sodium nimbidinate | (Sharma and Saksena 1959) |
| | bitter principle | (Siddiqui 1942) |
| | nimbidin series | (Siddiqui and Mitra 1945) |
| | | (Siddiqui et al. 1975a) |
| | azadiradione | (Siddiqui et al. 1975b) |
| | 17-hydroxyazadiradion | (Siddiqui et al. 1978) |
| | nimocinol | (Siddiqui et al. 1984) |
| | tetranortriterpenoid | (Siddiqui et al. 1984) |
| | | (Siddiqui et al. 1986) |
| | | (Siddiqui et al. 1988) |
| mode of action | azadirachtin | (Sieber 1985) |
| general uses | | (Sinha and Gulati 1969) |
| contraceptive | | (Sinha et al. 1984) |
| poisoning | | (Sinniah and Baskaran 1981) |
| | fatty acids | (Skellon et al. 1962) |
| sunlight effect | azadirachtin | (Stokes and Redfern 1982) |
| | kaempterol-3-glucoside | (Subramanian and Nair 1972) |
| | myricetin-3-1-arabinoside | (Subramanian and Nair 1972) |
| | quercetin-3-galactoside | (Subramanian and Nair 1972) |
| cardiovascular | | (Thompson and Anderson 1978) |
| | chemical constituents | (Tirimanna 1983) |
| | azadirachtin | (Uebel et al. 1979) |
| pests of neem | | (Uthamasamy et al. 1973) |
| antifeedant | nimbidin | (Verma 1974) |
| antifeedant | nimbin | (Verma 1974) |
| | | (Warthen 1979) |
| | azadirachtin | (Warthen et al. 1984) |
| nitrogen fixing | | (Watanabe et al. 1981) |
| | azadirachtin | (Yamasaki et al. 1986) |
| phagorepellent | azadirachtin | (Zanno 1974) |
| growth disruptor | azadirachtin | (Zanno 1974) |
| systemic | azadirachtin | (Zanno 1974) |
| | nimbin | (Ziffer et al. 1966) |

citations; the review by Warthen (1979) contained 105 citations. Within the Phylum Arthropoda, 7 Orders are represented in Class Insecta with Hymenoptera being a new order affected by neem. Since the review by Warthen (1979), additional species affected by neem have been added to the literature: 11 in Coleoptera, 9 in Diptera, 4 in Heteroptera, 3 in Homoptera, 22 in Lepidoptera, and 2 in Orthoptera.

Although literature is extensive and progress in research has been accomplished, the commercial development of a marketable natural insect pest control agent has been painstakingly slow. However, the novel chemistry within these literature citations pertaining to neem has been a stimulus to chemists to synthesize active analogs that might have the possibility for commercial development as insect feeding deterrents or growth regulators.

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# NOTES ON *PLEUROLITHOBIUS* OF TURKEY (CHILOPODA: LITHOBIOMORPHA)

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*Abstract.*—The Turkish centipedes belonging to *Pleurolithobius* Verhoeff, 1899 are listed and discussed: *P. jonicus* Silvestri, 1896, previously known only through doubtful data, and *P. orientis* (Chamberlin, 1952) (n. comb.), previously recorded only on the original description, are fully redescribed and new faunistic data are given.

The following new synonymies are proposed: *Turkobius* Chamberlin, 1952 = *Pleurolithobius* Verhoeff, 1899; *Archilithobius integrior caducus* Chamberlin, 1952 = *Pleurolithobius orientis* (Chamberlin, 1952); *Pleurolithobius atopior* Chamberlin, 1952 = *Pleurolithobius orientis* (Chamberlin, 1952).

*Key Words:* centipedes, *Pleurolithobius*

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The object of this paper is to summarize our knowledge of the species of the genus *Pleurolithobius* Verhoeff, 1899 presently known from Turkey (as politically constituted today). Two taxa are recognized for this area: *P. jonicus* Silvestri, 1894 and *P. orientis* (Chamberlin, 1957).

For each taxon, literature records for the study area are reported, material examined is listed geographically from N to S and from W to E, geographical distribution is discussed, description of material examined including taxonomical notes is provided.

The following abbreviations have been used: MZ = coll. M. Zapparoli; W = coll. R. V. Chamberlin, National Museum of Natural History, Smithsonian Institution, Washington; vil. = vilayet (= province).

The original labels accompanying the type specimens are quoted integrally and indicated in quotation marks (" ").

*Pleurolithobius jonicus* Silvestri, 1896

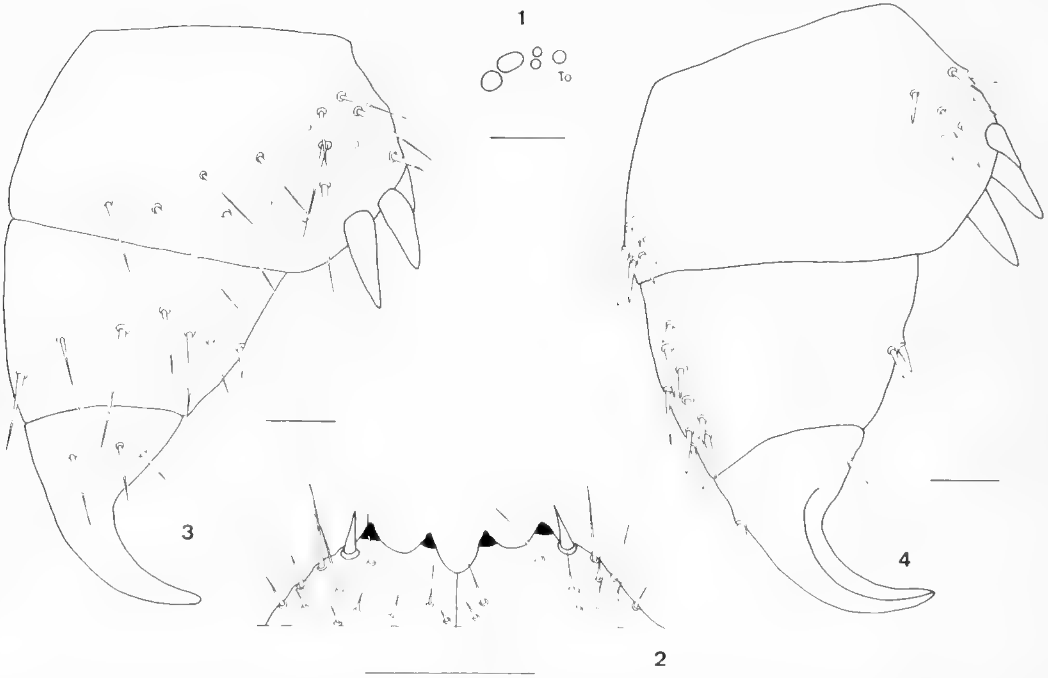
?*Pleurolithobius jonicus:* Matic, 1980: 98.

Material examined.—1 ♀, vil. Canakkale, Truva, m 70, 23.IV.1982, A. Vigna leg. (MZ); 4 ♀♀, vil. Canakkale, dint. Ayvacik, m 350, 23.IV.1982, M. Bologna leg. (MZ); 3 ♂♂, 4 ♀♀, ibidem, A. Vigna leg. (MZ); 4 ♂♂, 1 ♀, ibidem, M. Zapparoli leg. (MZ); 1 ♀, vil. Izmir, Izmir, 15.IV.1973, V. Sbordoni leg. (MZ); 1 ♂, 1 ♀, vil. Balikesir, dint. Havran, 50 km prima di Balikesir, m 450, 23.IV.1982, M. Zapparoli leg. (MZ).

Distribution.—Southern Italy (excl. Sicily), southern Yugoslavia (Montenegro), Albania, mainland Greece and Ionian Islands, southern Bulgaria and western Anatolia. Matic and Golemansky (1964) record *P. jonicus* from Crete, but this record is doubtful and needs confirmation.

Description.—Size 9.5–12.0 mm long, 1.25–1.27 mm broad at T. 10; color light brown.

Head slightly wrinkled, broader than long and broader than T. 1, posterior border straight, posterior marginal ridge with median thickening, lateral marginal interrup-



Figs. 1–4. *Pleurolithobius jonicus* Silvestri, 1896 (Ayvacik). 1, Right ocelli and organ of Tömösvary (Tö). 2, Dental margin of prosternum, ventral. 3, Right female gonopod, ventral. 4, Left female gonopod, dorsal. Scales: 1—0.2 mm; 2–4—0.1 mm.

tions present; antennae about a third of body length with 32–41 articles, the terminal one about 2–3 times as long as penultimate; ocelli 1+1,2 (Fig. 1), depigmented or slightly pigmented, postero-superior ocellus about the same size of principal ocellus, organ of Tömösvary of the same size or slightly larger than secondary ocelli; prosternum (Fig. 2) with 2+2 teeth, porodont setiform, lateral to porodont the shoulders are absent or barely distinct.

Tergites slightly wrinkled; T. 1 broader than T. 3, almost rectangular with posterior border straight or slightly sinuated; lateral border parallel in TT. 3, 5, 7 and 8, slightly convergent posteriorly in T. 10, posteriorly convergent in TT. 12 and 14; posterior angles rounded in TT. 3, 5, 7 and 8, angled in TT. 10, 12 and 14; posterior border straight or slightly sinuated in TT. 3, 5 and 7, sinuated in TT. 8 and 10, emarginate in T. 12, straight or emarginate in T. 14; TT. 9 and 11 without triangular projections on the posterior angles, T. 13 generally without triangular projections, sometimes only slightly produced; intermediate tergites with rounded posterior angles and straight posterior border; T. 16 of the male with lobate projection at the posterior angles as figured in Matic and Golemansky (1964: fig. 1).

Anterior legs with tarsal articulations distinct, see Table 1 (♂♂) and Table 2 (♀♀) for spinulation; coxal pores 4,3,3,2 or 4,3,3,3 (♂♂), 5,4,4,4 or 4,4,4,4 (♀♀), circular, separated from one another by a space equal, greater or smaller than their own diameter, females with proximal pore of coxae XII generally smaller; males with femur and tibia XIII evidently thickened (see Matic and Golemansky 1964: fig. 1), XIV legs not thickened, male with distal end of tibia XV with dorsolateral swelling bearing a tuft of

Table 1. *Pleurolithobius jonicus* Silvestri, 1896. Spinulation (*), ♂♂; letters in parentheses indicate variable spines.

| | Ventral | | | | | Dorsal | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | tr | P | F | T | C | tr | P | F | T |
| 1 | — | — | — | — | m | — | — | (p) | a | a |
| 2 | — | — | — | (m) | m | — | — | (p) | a(p) | a |
| 3 | — | — | — | (m) | m | — | — | (p) | ap | a |
| 4 | — | — | — | (a)m | m | — | — | (p) | ap | a(p) |
| 5 | — | — | — | (a)m | (a)m | — | — | (p) | ap | ap |
| 6 | — | — | — | am | am | — | — | (p) | ap | ap |
| 7–8 | — | — | (m) | am | am | — | — | (p) | ap | ap |
| 9 | — | — | m(p) | am(p) | am | — | — | (p) | ap | ap |
| 10 | — | — | m(p) | am(p) | am | — | — | (m)p | ap | ap |
| 11 | — | — | m(p) | am(p) | am | — | — | (m)p | (a)p | (a)p |
| 12 | — | — | mp | am(p) | am | — | — | mp | p | p |
| 13 | — | (m) | mp | m | m | — | — | (m)p | p | — |
| 14 | — | m | mp | m | m | — | — | mp | p | — |
| 15 | — | m | m(p) | m | — | — | — | mp | p | — |

* C = coxa, tr = trochanter, P = prefemur, F = femur, T = tibia; a = anterior spur, m = medial, p = posterior.

some setae (see Matic and Golemansky 1964: fig. 1), male with DpP XV spine inserted on the latero-internal side of the article, females with DpP XV spine normally positioned; females with XIII–XV legs without special modifications; apical claw of XV legs with accessory claw one-half or two-thirds of the principal claw length; glandular pores on XII–XV legs.

Male first genital sternite with 8–10 setae, second genital sternite without setae, gonopods without apical setae.

Female gonopods (Figs. 3 and 4) with 3+3 long conical spurs, progressively longer and larger from the internal one to the external, internal spur generally lying behind the intermediate spur, apical claw narrow and without lateral denticles; basal article with a group of 6 relatively strong dorsolateral setae and a group of 6–7 dorsomedial setae, as strong as the dorsolateral setae, positioned near the insertion of the spurs, second article with 7–9 dorsolateral setae arranged in two rows and two dorsomedial

Table 2. *Pleurolithobius jonicus* Silvestri, 1896. Spinulation, ♀♀; letters in parentheses indicate variable spines. See Table 1 for codes explanation.

| | Ventral | | | | | Dorsal | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | tr | P | F | T | C | tr | P | F | T |
| 1 | — | — | — | (a) | (a)(m) | — | — | (p) | a(p) | a |
| 2 | — | — | — | (a)(m) | (a)m | — | — | (p) | ap | a |
| 3 | — | — | — | am | (a)m | — | — | (p) | ap | a |
| 4–7 | — | — | — | am | am | — | — | (p) | ap | ap |
| 8 | — | — | mp | amp | am | — | — | (p) | ap | ap |
| 9 | — | — | mp | amp | am | — | — | (m)p | ap | ap |
| 10 | — | — | mp | amp | am | — | — | mp | (a)p | ap |
| 11 | — | — | mp | amp | am | — | — | mp | p | ap |
| 12 | — | — | mp | amp | am | — | — | mp | p | (a)p |
| 13 | — | (m) | mp | amp | am | — | — | mp | p | p |
| 14 | — | m | mp | amp | am | — | — | mp | p | p |
| 15 | — | m | m(p) | (a)m | — | — | — | mp | p | (p) |

setae, apical claw with two dorsolateral setae and one dorsomedial seta.

Remarks.—The only known record for Turkey for this species is from Uskudar (vil. Istanbul) (Matic 1980). However, the author doesn't mention the sex or the number of specimens recorded; this record is dubious since it is possible that it might be referred to the next species, *P. orientis*, with females apparently indistinguishable from those of *P. jonicus* and type-locality (Polonezköy) very close to the locality of the Matic (1980) record.

The presence of *P. jonicus* in Turkey is however confirmed by the material recorded here.

The ecology of *P. jonicus* is little known. Minelli and Iovane (1987) stated for the Italian populations the general preference of this species for open habitats, from sea level up to 250 m; Matic and Golemansky (1965) define this species as a "eurybionte"; moreover Matic and Golemansky's (1964, 1965) Bulgarian records have been collected between 340–500 m. The Turkish specimens here recorded were collected in calcareous soils, between 50 and 450 m, in anthropized habitat (Truva), arid open land with *Quercus* gr. *coccifera* Linnè and *Juniperus* sp. (Ayvacik) and in pine-wood (Havran).

### *Pleurolithobius orientis* (Chamberlin, 1952) NEW COMBINATION

*Turkobius orientis* Chamberlin, 1952: 225.
*Archilithobius integrior caducus* Chamberlin, 1952: 236 syn. nov.
*Pleurolithobius atopior* Chamberlin, 1952: 254 syn. nov.

Material examined.—2 ♂♂, 1 ♀, vil. Istanbul, Belgrat Ormani, m 100, Büyükdere, 17.V.1987, A. Vigna leg.; 2 ♂♂, 9 ♀♀, vil. Istanbul, ibidem, M. Zapparoli leg. (MZ); 1 ♀ (Holotypus), "*L. orientis*, ♀, type, Polonezkö, 15.V.48," "43–642" (W); 1 ♂ (here formally designated as Lectotypus of *Pleurolithobius atopior* Chamberlin, 1952), 1 ♂ (here formally designated Paralectotypus of *Pleurolithobius atopior* Chamberlin, 1952), "*Pleurolithobius atopior* Ch., Types, Polonezköy, 15.V.48," "51–794" (W).

Distribution.—Species formerly known only for its type locality, Polonezköy, and Yalova, both on the Asiatic side of the vil. Istanbul. *P. orientis* is here recorded for the first time on the European side of Turkey. This species is also known for the islands of Kos and Leros (southern Sporades Archipelago) (M. Zapparoli, unpublished data).

Description of the holotypus.—Female. Size 19 mm long, 2.7 mm broad at T. 10; color chestnut.

Head smooth, 3.3 mm broad, 3.0 mm long, posterior border almost straight, posterior marginal ridge with median thickening; antennae 5.5 mm long, with 39 articles (right), left antenna mutilated, the first 3–4 proximal articles large, the next ones are longer than broader, last article about three times as long as penultimate; ocelli 1+1,2 depigmented, principal ocellus not contiguous with the secondary ocelli, postero-superior ocellus larger than principal ocellus; organ of Tömösvary of the same size as the postero-superior ocellus; the forcipules are absent probably because dissected by Chamberlin, since they are drawn in the original work (Chamberlin 1952: fig. 31).

Tergites wrinkled; T. 1 subrectangular, narrower than T. 3, posterior border slightly sinuate; lateral borders parallel in TT. 3, 5, 7 and 8, slightly posteriorly convergent in T. 10, posteriorly convergent in TT. 12 and 14; posterior border slightly sinuate in TT. 3, 5 and 8, straight in T. 7, slightly emarginated in TT. 10 and 12, emarginated in T. 14; posterior angles rounded in TT. 3, 5 and 8, squared in TT. 7, 10, 12 and 14; TT. 9 and 11 without triangular projection on the posterior angles, T. 13 with slight projection; intermediate tergite with posterior borders almost straight.

Anterior legs with tarsal articulations distinct, see Table 3 for spinulation; coxal pores 5,4,4,4, circular and separated one from

Table 3. *Pleurolithobius orientis* (Chamberlin, 1952). Holotypus: spinulation. See Table 1 for codes explanation.

| | Ventral | | | | | Dorsal | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | tr | P | F | T | C | tr | P | F | T |
| 1 | — | — | — | — | a | — | — | p | a | a |
| 2 | — | — | — | — | am | — | — | p | ap | a |
| 3–5 | — | — | — | am | am | — | — | p | ap | a |
| 6–7 | — | — | — | am | am | — | — | p | ap | ap |
| 8–9 | — | — | m | am | am | — | — | p | ap | ap |
| 10 | — | — | mp | am | am | — | — | mp | p | ap |
| 11 | — | — | mp | amp | am | — | — | mp | p | ap |
| 12–13 | — | m | mp | amp | am | — | — | mp | p | p |
| 14 | — | m | amp | amp | am | — | — | mp | p | p |
| 15 | — | m | amp | am | — | — | — | mp | p | — |

another by a space little larger than their own diameter, the proximal porus relatively smaller than the other; XV legs 4 mm long, apical claw with accessory claw about one-half as long as the principal claw; glandular pores on XII–XV legs, those of femur and tibia XIII sparse and evident.

Gonopods with 3+3 long spurs, the inner one relatively shorter than the others, apical claw narrow and without lateral denticles.

A redescription of the male, based on the Lectotypus of *P. atopior,* follows.

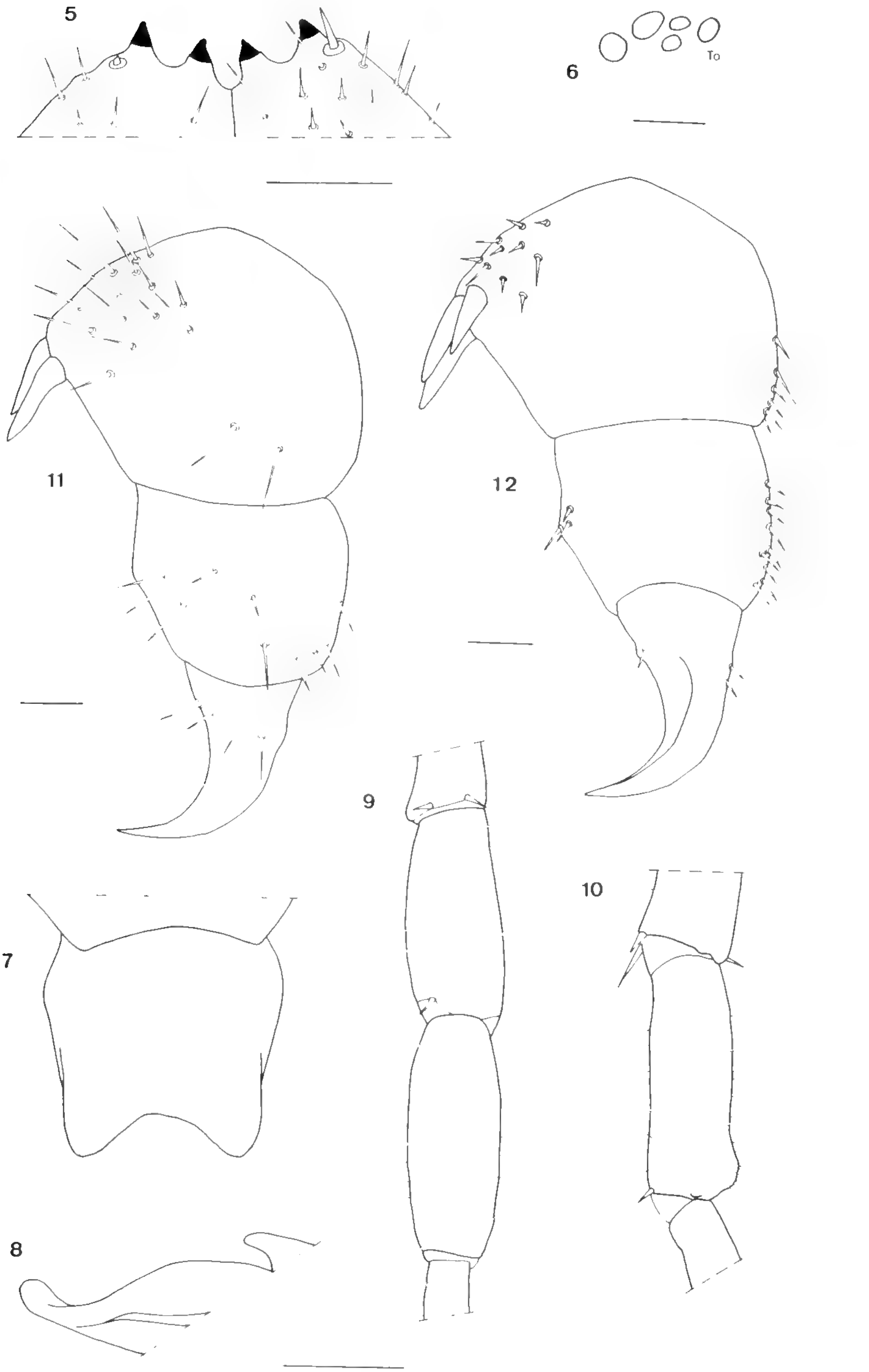
Size 12.50 mm long, 1.75 mm broad at T. 10; color chestnut.

Head as broad as long, posterior border almost straight, posterior marginal ridge with median thickening; antennae 5.0 mm long, with 39 articles (left), right antenna mutilated at the level of article 22, the proximal 3–4 articles larger, the following ones are as broad as long, last article about three times as long as the penultimate; ocelli 1+1,2, depigmented, the two posterior ocelli about twice larger than the two anterior ones; organ of Tömösvary smaller than one anterior ocellus; the forcipules are absent, probably because they were dissected by Chamberlin, since they are figured in the original work (Chamberlin 1952: fig. 44).

Tergites wrinkled; T. 1 subrectangular, smaller than T. 3, posterior border slightly sinuate; lateral borders parallel in TT. 3, 5, 7 and 8, slightly posteriorly convergent in T. 10, posteriorly convergent in TT. 12 and 14; posterior border slightly sinuate in T. 3, sinuate in T. 5, straight in T. 5, slightly emarginate in TT. 8, 10 and 12, emarginate in T. 14; posterior angles rounded in TT. 3, 5, 7 and 8, squared in TT. 10, 12 and 14; TT. 9 and 11 without triangular projections on the posterior angles, T. 13 with feebly projection; intermediate tergites with posterior border almost straight; last tergite with lateral border posteriorly convergent, posterior border deeply concave, posterior angles rounded, posteriorly projected and rising slightly.

Anterior legs with tarsal articulation; coxal pores 4,4,3,2, circular and separated one from another by a space little larger than their own diameter, proximal pore of XII and XIII coxae smaller than the other and near the next pore; femur and tibia of XIII legs thickened (cf. Fig. 9), femur little thicker than tibia and with a dorsal median sulcus not reaching the ends of the article; XIV legs little thickened but without special structures; XV legs 3.5 mm long, tibia with a dorsolateral lobe bearing some setae at the distal end of the article, DpP spine inserted on the internal lateral side of the article, apical claw with accessory apical claw about one-half as long as the principal claw; glandular pores XII–XV legs, those of femur and tibia XIII very evident and rather sparse.

First genital sternite with 17–18 setae rel-



Figs. 5–12. *Pleurolithobius orientis* (Chamberlin, 1952) (Belgrat Ormani). 5, Dental margin of prosternum, ventral. 6, Right ocelli and organ of Tömösvary (Tö). 7, Last male tergite, dorsal. 8, Last male tergite, lateral. 9, Male XIII femur and tibia, dorsal. 10, Male XV tibia, dorsal. 11, Left female gonopod, ventral. 12, Right female gonopod, dorsal. Scales: 5–0.1 mm; 6–0.2 mm; 7–10–0.5 mm; 11–12–0.1 mm.

Table 4. *Pleurolithobius orientis* (Chamberlin, 1952). Spinulation, ♂♂ (Belgrat Ormani); letters in parentheses indicate variable spines. See Table 1 for codes explanation.

| | Ventral | | | | | Dorsal | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | tr | P | F | T | C | tr | P | F | T |
| 1 | — | — | — | — | m | — | — | p | a | a |
| 2 | — | — | — | — | m | — | — | p | a | a |
| 3 | — | — | — | a | m | — | — | p | ap | a |
| 4–7 | — | — | — | am | am | — | — | p | ap | ap |
| 8–9 | — | — | mp | am | am | — | — | (m)p | ap | ap |
| 10 | — | — | mp | am | am | — | — | mp | ap | ap |
| 11 | — | — | mp | amp | am | — | — | mp | ap | ap |
| 12 | — | m | mp | am(p) | am | — | — | mp | ap | ap |
| 13 | — | m | mp | am(p) | am | — | — | mp | p | p |
| 14 | — | m | mp | am(p) | a | — | — | mp | p | p |
| 15 | — | m | m(p) | (a)m | — | — | — | mp | p | — |

atively long; second genital sternite without setae; gonopods short and with one apical seta.

The specimens from Belgrat Ormani (Büyükdere, vil. Istanbul) differ from the samples described above in the following characters.

Size 14.0–18.5 mm long, color dark chestnut. Antennae with 36–42 articles; prosternum (Fig. 5) with evident shoulders, relatively smaller in males than in females; ocelli as in Fig. 6.

Tergites, especially the posterior ones, with numerous sparse, relatively long setae; T. 9 without triangular projection to the posterior angles, T. 11 generally without triangular projections, very little projection when present, T. 13 with very slightly triangular projections. Male last tergite as in Figs. 7 and 8.

See Tables 4 (♂♂) and 5 (♀♀) for spinulation. Female with DpP normally positioned; legs with numerous dorsal sparse setae; coxal pores 5,4,4,4 (♀♀), 4,3,3,2 or 3,3,3,2 (♂♂). XIV and XV legs of the only male without multilation both 4.6 mm long, female with XIV legs 3.9–4.5 mm long and XV legs 4.9–5.2 mm long; femur and tibia XIII and tibia XV figured in Figs. 9 and 10.

Female gonopods (Figs. 11 and 12) with

Table 5. *Pleurolithobius orientis* (Chamberlin, 1952). Spinulation, ♀♀ (Belgrat Ormani); letters in parentheses indicate variable spines. See Table 1 for codes explanation.

| | Ventral | | | | | Dorsal | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | tr | P | F | T | C | tr | P | F | T |
| 1 | — | — | — | (a)(m) | (a)m | — | — | (p) | a | a(p) |
| 2 | — | — | — | a(m) | am | — | — | (p) | (a)p | a(p) |
| 3 | — | — | — | am | am | — | — | (p) | ap | a(p) |
| 4–5 | — | — | — | am | am | — | — | (p) | ap | ap |
| 6–7 | — | — | m(p) | am(p) | am | — | — | (p) | ap | ap |
| 8 | — | — | mp | am(p) | am | — | — | (m)p | ap | ap |
| 9 | — | — | mp | amp | am | — | — | (m)p | ap | ap |
| 10 | — | — | mp | amp | am | — | — | mp | ap | ap |
| 11 | — | (m) | mp | amp | am | — | — | mp | ap | ap |
| 12 | — | m | (a)mp | amp | am | — | — | mp | p | ap |
| 13 | — | m | (a)mp | amp | am | — | — | mp | p | (a)p |
| 14 | — | m | (a)mp | amp | am | — | — | mp | p | p |
| 15 | — | m | amp | am | — | — | — | mp | p | — |

3+3 long spur, exceptionally 4+3, progressively longer from the internal one to the external one, internal spur generally lying behind the other two; apical claw narrow and without lateral denticles; basal article with a row of 6–7 dorsolateral setae and a group of 10–11 setae positioned near the insertion of the spurs, second article with 9–11 dorsolateral setae arranged in two rows, and three dorsomedial setae, apical claw with 2–3 dorsolateral setae and one dorsomedial seta.

Remarks.—Chamberlin (1952) based his description of *P. orientis* on two females, one from Polonezköy (Holotypus) and one from Yalova; he designated this species as the type species of the genus *Turkobius* Chamberlin, 1952, which he described as new and assigned to the family Gosibiidae. In the genus *Turkobius,* Chamberlin (1952) includes eight species divided into two subgenera, *Turkobius* s. str. and *Alibius* Chamberlin, 1952.

Based on examination of the Holotypus, *T. orientis* must be referred to the genus *Pleurolithobius* as defined by Verhoeff (1899), and the following new synonymy is proposed: *Turkobius* s. str. Chamberlin, 1952 = *Pleurolithobius* Verhoeff, 1899 syn. nov.

It is not the aim of this work to discuss the identity of the other species referred by Chamberlin (1952) to *Turkobius*; however it is suitable to point out that these taxa belong to Lithobiidae and are certainly unrelated to *Pleurolithobius.* In fact some taxa belong to *Lithobius* s. str. (those described under *Turkobius* s. str., with the exception of *T. orientis*), and others are referable to a taxon of subgeneric rank of the genus *Lithobius* Leach, 1814 (those described under *Alibius*). The identity of *Turkobius* and the species which Chamberlin (1952) included in this taxon will be discussed in a paper now in preparation.

Chamberlin (1952) has described, on the basis of a female from Polonezköy, *Lithobius integrior caducus.* This taxon was originally referred to the genus *Archilithobius* Stuxberg, 1875 (now considered identical with *Lithobius*) and was considered at specific rank in the key that the author (Chamberlin 1952) gave for the Turkish species.

The identity of *L. integrior caducus* cannot be discussed on the basis of the type specimens since the material has been lost (J. Coddington in litt. 1987). The following considerations are therefore based only on the very incomplete original description.

The few characters given by Chamberlin (1952) for *L. integrior caducus* (especially the shape of the prosternum and the shape of the apical claw of female gonopods) fall well within the variability of *P. orientis* described above, and the two forms are difficult to distinguish one from another. Moreover, noting not only the precise coincidence of the type-localities of the two taxa, but also the identity of the collecting date of the samples, it is quite justifiable to suppose that the female described as *L. integrior caducus* and the Holotypus of *P. orientis* might both likely refer to the same population.

Therefore, the following new synonymy is proposed: *Archilithobius integrior caducus* Chamberlin, 1952 = *Pleurolithobius orientis* (Chamberlin, 1952) syn. nov.

Another species described by Chamberlin (1952) on material (two males) collected in the same type-locality and on the same day as *P. orientis* and *L. integrior caducus* is *P. atopior.* Holotypus and Paratypus of this species are not indicated in the original work; however two specimens, here examined, labelled "*Pleurolithobius atopior* Ch., Types, Polonezköy, 15.V.48," preserved in Chamberlin's collection in the National Museum of Natural History of Washington and agreeing with Chamberlin's description of *P. atopior,* represent undoubtedly the syntypical series of this taxon. Therefore these specimens are here formally designated respectively as Lectotypus and Paralectotypus of *P. atopior.*

Based on the study of the type specimens of *P. atopior* it was possible to verify the identity of the characters of this taxon with those here described for the male of *P. orientis.* Consequently, the following new synonymy is proposed: *Pleurolithobius atopior* Chamberlin, 1952 = *Pleurolithobius orientis* (Chamberlin, 1952) syn. nov.

As Chamberlin (1952) already stated in his brief discussion on the morphological affinities of *P. atopior, P. orientis* is close to *P. jonicus* and is distinguishable from this species by the shape of the last tergite of the male, without lobed projection on the posterior angles. However, this character cannot be used for identification of the females of the two species that, as already stated, are apparently indistinguishable one from another.

On the basis of the material examined it is, however, possible to show some characters useful to distinguish easily, at least for the Anatolian populations, the females of *P. jonicus* from those of *P. orientis.* These characters are: body generally smaller (length 9.5–12.0 mm), prosternal shoulder feeble or absent (Fig. 2), T. 1 subrectangular and terminal tergites without sparse setae in *P. jonicus*; body generally larger (length 14.0–18.5 mm), prosternal shoulder present (Fig. 5), T. 1 trapezoidal and terminal tergites with sparse setae in *P. orientis.*

The ecology of *P. orientis* is practically unknown. This species has been collected at very low altitudes (100–200 m); the samples from Belgrat Ormani were collected in litter of mixed woodland composed essentially of *Acer* spp., *Quercus* spp., *Fagus orientalis* Lipsky and *Castanea sativa* Miller, with an undergrowth characterized by *Smilax* sp., *Crataegus* sp. and *Erica* sp.

Another species recorded for the Turkish fauna and originally described under *Pleurolithobius* is *Lithobius argaeensis* Attems, 1905, known for Ercjias Daği (vil. Kayseri) (type-locality) and in some localities of Iran (Attems 1905, 1951, Brölemann 1921). Therefore, the original generic classification of this species is wrong and has not been followed by the following authors. In fact, Brölemann (1921) and Attems (1951) correctly considered this species under *Monotarsobius* Verhoeff, 1905.

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I wish to thank Dr. J. A. Coddington, of the National Museum of Natural History, Smithsonian Institution, Washington, and Prof. A. Vigna Taglianti, Director of the Zoological Museum of the Dipartimento di Biologia Animale e dell'Uomo of Rome University "La Sapienza," for enabling me to examine specimens in their charge.

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# REVIEW OF *GOYA* RAGONOT AND DESCRIPTION OF A NEW SPECIES, *G. SIMULATA* FROM PARANÁ, BRAZIL (LEPIDOPTERA: PYRALIDAE: PEORIINAE)

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*Abstract.*—***Goya simulata*** is described from Curitiba, Paraná, Brazil. Included are photographs of adult moths, head profiles, genitalia of both sexes, scanning electron micrographs of male antennae, and a discussion of the genus with a key to the four known species. *G. simulata* is compared with the male holotype of the presumably sympatric sibling species, *G. albivenella* and with the female lectotype of its junior synonym *G. cancelliella.*

*Key Words:* *Goya albivenella, G. cancelliella, G. stictella, G. ovaliger,* taxonomy, neotropical lepidoptera

While recently examining a series of Brazilian pyralid moths from the collection of Dr. Vitor Becker, I sorted out six specimens from Paraná which appeared to belong to *Goya albivenella* Ragonot, 1888. This species is known only from the male type and, if the association is correct, 2 nontopotypic females. On examination of the genitalia it was clear that the 2 males in the series were specifically different from *albivenella* and represented an undescribed species. The 4 females are likewise distinctly different in genital characteristics from specimens presumed to be *albivenella.* The new species is described below.

*Goya* Ragonot, 1888 was erected for two species, including *G. albivenella,* described from Goya, Corrientes, Argentina, and subsequently designated as the type of the genus (Hampson in Ragonot, 1901: 349). The other originally included species is African, clearly peoriine, but of uncertain generic affinity as it is known only from the female type, not yet associated with male specimens. Shaffer (1968: 56) transferred *Saluria stictella* Hampson, 1918 to *Goya,* and *Atopothoures ovaliger* Blanchard, 1975 was shifted to *Goya* (Blanchard, 1978: 55), with *Atopothoures* Blanchard, 1975 becoming a junior synonym of *Goya.*

The last redescription of the genus (Shaffer 1968: 56) was based on the 2 species known at the time. With the discovery of 2 additional species, the distinction between specific and generic characters becomes more apparent, and it seems worthwhile to comment on these. In all 4 species the uncus possesses a medial process of variable shape and armament, but always with a pair of posteriorly directed spines along the caudal margin. These spines are large in the 2 North American species, moderate in *albivenella* (Fig. 18), and small in *simulata* (Fig. 13 s). The paired lateral processes of the uncus are rhomboidal, pad-like, sparsely setose, and vary little from species to species. They are unusual apomorphies unlike those of any other known peoriine. The medial process of the gnathos is unique in detail for each species, but very close in the two North American ones and subject to individual variation (see below). Also, its appearance

Figs. 1–4. *Goya simulata.* 1, ♂ holotype; 2, ♂ holotype, head, lateral view; 3, ♀ paratype coll. 25 XII 1974; 4, ♀ paratype coll. 4 II 1975, head, lateral view. Scale bar = 2.0 mm (1, 3), 1.0 mm (2, 4).

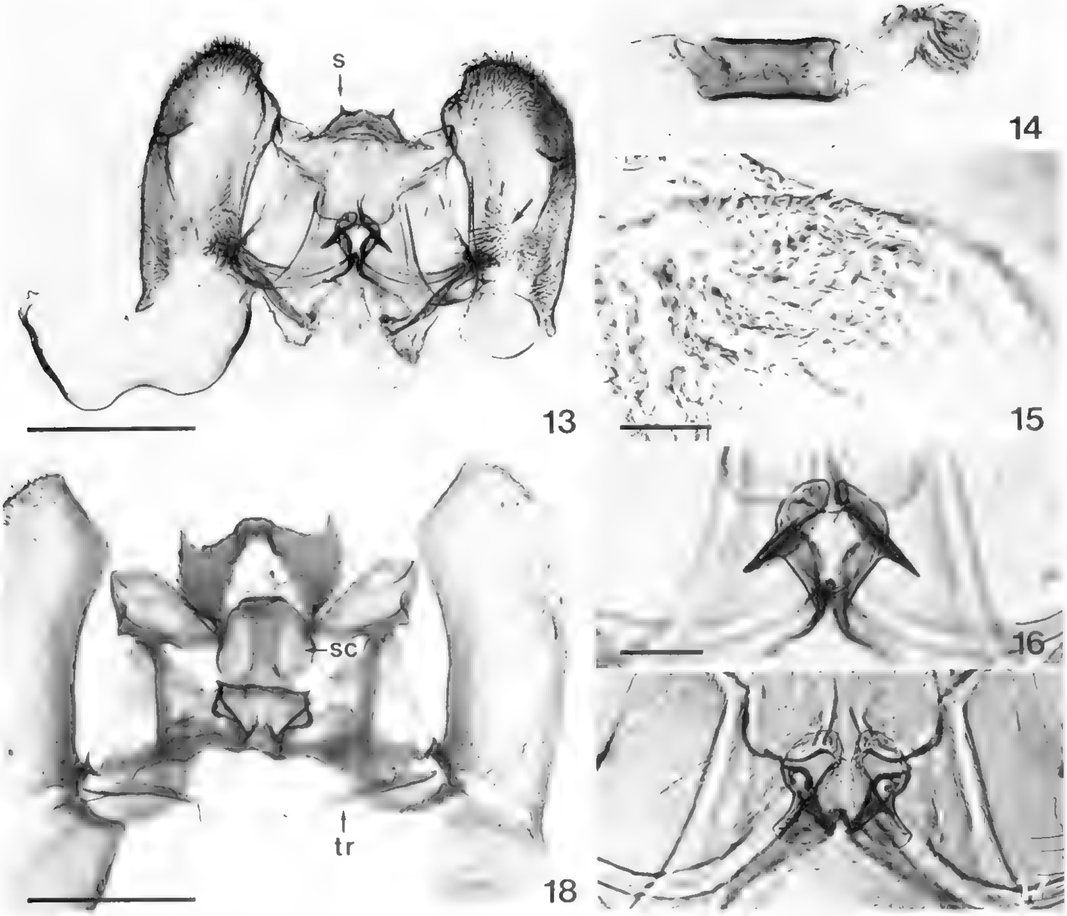
on prepared slides varies much depending on the extent to which it is compressed by the coverglass. Compare, for example, Figs. 16 and 17. These appear quite different because the flaps seen on edge in Fig. 16 were flattened in the other preparation and so appear broadside. A stereoscopic view of the actual preparations reveals them to be essentially identical. Few peoriines have the transtilla developed, but in *Goya* it is present in all four species, incomplete and in the form of simple narrow bars (Figs. 13, 18 tr). The valve shows relatively minor interspecific variation, always more or less parallel sided, apically diagonally truncate, and unarmed. The aedeagus is simple, variable in shape, always short; it and the vesica are always unarmed but for minute denticles.

The female genitalia of peoriines tend to be simple and rather uniform with the ovipositor compressed, the ostial chamber membranous and unmodified, and the signum only rarely present. Most often it is not possible to identify peoriine species on the basis of the female genitalia. Those of *Goya* generally fit the above pattern, but are distinct for each of the 4 species. Also, they exhibit two apomorphies each diagnostic of the genus. Most evident of the two is a large dorsocaudal sac on the 8th segment. It appears somewhat different in each species, but is in every case well developed. Similar

Figs. 5–12. *Goya simulata,* basal modification of male antennal shaft. 5–8, holotype, left antenna, showing 5, lateral; 6, anterior; 7, medial; and 8, posterior views. 9–12, paratype, left antenna partly denuded to show surface enclosed by scale tufts, same perspective as in 8. Scale bar = 500 μm (5–9), 50 μm (10), 25 μm (11), 5 μm (12).

features appear in two other New World peoriine genera. In *Atascosa* all 4 known species have a well developed narrow digitate invagination in this position (see Shaffer 1976, Plate 14e, g, i), and females of *Coenotropa* have paired short pouches (ibid., Plate 14b, c) in the same place. The markedly different development of these sacs suggests an independent development for each genus.

The other apomorphy is more easily overlooked. The 7–8 intersegmental membrane is dorsally thickened and folded so as to form an anterodorsal pocket at the an-

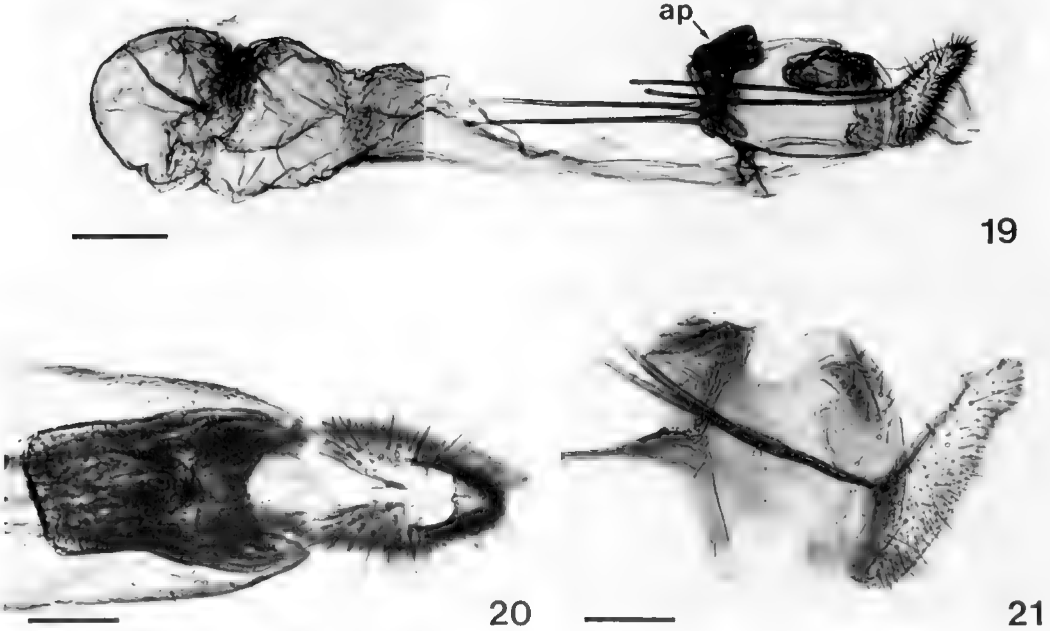


Figs. 13–18. Male genitalia. 13–16, *Goya simulata,* holotype; 13, male genitalia (aedeagus omitted); 14, aedeagus; 15, detail of vesica enlarged to show denticles; 16, medial process of gnathos; 17, paratype, medial process of gnathos, compressed by coverglass; 18, *G. albivenella,* lectotype, s = uncus spine, sc = subscaphium, tr = transtilla. Scale bar = 1 mm (13, 14), 0.05 mm (15), 0.2 mm (16, 17), 0.5 mm (18).

terior of the 8th segment collar. This feature is present in all four species and is illustrated for *simulata* in Fig. 19 (ap).

Distributions of *Goya* spp.—Two species are North American. *G. stictella* was described from Andros Island, Bahamas and is represented from Florida, Mississippi, Arkansas, and Texas. Blanchard's *ovaliger* is so far known only from Texas. He and I have collected both species by blacklight at the Welder Wildlife Refuge near Sinton, Texas. Either or both may range into Mexico, but are yet unknown there. *G. albivenella* is known with certainty only from the type locality, Goya, Corrientes, Argentina, but the two female specimens from Espirito Santo and Pernambuco, Brazil are likely conspecific. The latter (Fig. 21) is the lectotype of *cancelliella* (Ragonot), a junior synonym of *albivenella,* and is clearly distinct from females of *simulata. G. simulata* is described from the state of Paraná, Brazil. The holotype and female paratypes are from Curitiba and the male paratype is from Quatro Barras, about 100 km to the east.

The 2 North American species, if in rea-



Figs. 19–21. Female genitalia. 19, *Goya simulata*, paratype, USNM slide 57903, lateral view; 20, same, dorsal view of eighth segment modification; 21, *G. albivenella*, lectotype of its junior synonym *G. cancelliella* (Ragonot), J. Shaffer slide 1181, lateral view. ap = anterodorsal pouch. Scale bar = 0.5 mm (19), 0.2 mm (20, 21).

sonably good condition, are readily distinguished by wing pattern, whereas the genital differences are minor and show overlapping individual variation. The 2 South American species are very close in wing pattern, and larger series of specimens will have to be examined to properly assess individual variation. Fortunately, the two species have distinctly different genitalia in both sexes.

### KEY TO SPECIES OF *GOYA*

1. Forewing with well developed spots or transverse bands; ♂ genitalia with subscaphium weakly sclerotized; aedeagus strongly flared basally in vertical plane; North American 2
– Forewing lacking well developed spots or transverse bands, veins prominently traced with white; ♂ genitalia with subscaphium well sclerotized, prominent, shield shaped (Fig. 18sc); aedeagus subcylindrical, not flared; South American 3
2. Forewing with well developed continuous antemedial and postmedial lines, discocellular spot a dark circle with pale center; medial process of gnathos usually with >2 denticles per side ................................ *ovaliger*
– Forewing lacking developed antemedial line; postmedial line discontinuous, formed of spots; discal spot small, solid; large dark spot on 2nd A posterior to cell; medial process of gnathos usually with 0–2 denticles per side ...... *stictella*
3. ♂ genitalia with medial process of uncus bearing numerous minute spines on ventral surface (Fig. 18); apical process of gnathos subquadrate; valve lacking patch of setae near base of costa (Fig. 18); ♀ genitalia with apophyses of normal length; 8th segment collar about as long as high; forewing 3rd A white-scaled ......... *albivenella*
– ♂ genitalia with medial process of uncus smooth but for pair of small spines on caudal margin (Fig. 13); apical process of gnathos cordate and strongly bilobed; valve with conspicuous patch of setae near base of costa (Fig. 13); ♀ genitalia with apophyses long; 8th segment collar about

1.7 times as long as high; forewing 3rd A with little or no white scaling .............. *simulata*

### *Goya simulata* Shaffer, New Species

Figs. 1–17, 19, 20

Diagnosis.—The single pair of very short uncus spines (Fig. 13 s) and the well developed hair tuft at the base of the valve costa (Fig. 13 diagonal arrow) are each unique to *simulata,* as are the unusually elongate eighth segment and apophyses of the female (Fig. 19).

Description.—Frons brown. Labial palpus obliquely ascending in both sexes; in male (Fig. 2) 2.6 times as long as eye diameter, 2nd segment narrow, gradually expanded distally (unrubbed condition), apically truncate; 3rd segment short, narrow, fusiform, set off from second; basal segment white, 2nd and 3rd segments brown dorsally, white ventrally, demarcation irregular; female (Fig. 4) similar to male, but unusually long and slender, 3.3–3.7 times as long as eye diameter. Maxillary palpus cylindrical, approaching end of frons, usually hidden by labials. Proboscis rudimentary. Male antenna shaft sublaminate, basal modification (Figs. 5–12) with segments partly fused, posterior surface with tuft of opposing bands of scales, unequal (cf. Figs. 5, 7), astride of and enclosing a surface that appears smooth at low magnification (Fig. 9), but at higher resolution irregularly carinate (Fig. 10), very finely rugose and mammillate (Figs. 11, 12). Female antenna filiform, unmodified. Eye diameter 0.85 mm (range: 0.75–0.95 mm). Ocellus well developed, elliptical, set obliquely to eye margin and separated from it by its own length. Vertex brown, bearing pad-like tuft of scales shielding antenna scapes anteromedially. Antenna sockets narrowly fringed with yellow scales laterally and posterolaterally. Occiput dark brown laterally; dorsally with erect wall of moderately dark brown scales behind antennae. Patagium and tegula with mixture of brown, dark brown, and yellowish brown scales.

Forewing radius 12–15 mm. Costa narrowly pale yellow, this color broadening near apex. Sc and radius traced with white; ground grayish red between costa and Sc and between Sc and radius. Ground of cell moderate yellowish brown with varying number of scattered black scales; this ground continuing between $R_5$ and $M_1$ to apex, but beyond cell with predominance of black so as to form dark dash between upper outer margin of cell and wing apex. A similar but much smaller dash extends from base of $Cu_2$ distally to near $M_2$–$M_3$ divergence. Cubitus traced with white, broadest near lower outer angle of cell, continuing distally on $M_2$, $M_3$, $Cu_1$, and $Cu_2$, broadest on $M_2$. Ground between cell ($Cu_2$ distal to cell) and 2nd A moderate yellowish brown. 1st A narrowly traced with white distal to cell. 2nd A broadly bordered on both sides with scattered blackish scales, weakly traced with white in some specimens (this feature might be more prominent in fresh specimens). Ground posterior to 2nd A varying from moderate yellowish brown to grayish red. Termen with conspicuous black spots between veins. Basal ⅓ of fringe yellow, distal ⅔ brown. $R_2$ basally approximate to $R_{3+5}$, contiguous in some specimens. $R_{3+4}$ fused, stalked with $R_5$ about half length of latter. $M_{2+3}$ from lower outer angle of cell, stalked nearly half its length.

Hindwing with $M_{2+3}$ stalked with $Cu_1$ nearly half length of latter.

Male genitalia (Figs. 13–17)—Uncus with lateral lobes about twice as long as wide; medial process rounded, smooth margined, armed only with a single pair of divergent short pointed cusps. Gnathos with medial process apically emarginate to about ⅕ its length and thus divided into a pair of lateral lobes, these lying in the plane of the lateral gnathos arms, each bearing ventral blade-like process set at about 90 degrees to plane of lateral gnathos arms (compare Figs. 16 and 17, the latter with these blades pressed flat in the preparation). Valve with a poorly defined cusp in midregion of cucculus, and strong patch of setae near base of costa (Fig. 13 arrow).

Female genitalia (Figs. 19, 20)—Apophyses long, straight, nearly equal in length, 2.0 times as long as 8th segment collar height and 1.3 times as long as its length. Dorsocaudal sac of 8th segment large, half as long as total 8th segment length. Ostial chamber, ductus bursae, and corpus bursae membranous, unmodified, unarmed.

Types.—Holotype: ♂ (Figs. 1, 2, 5–8, 13–16), labelled: "Curitiba, Paraná BRASIL—920m 20. XII. 1974 V. O. Becker Col."; "♂ genitalia on slide 2223 J. C. Shaffer"; "Holotype *Goya simulata* Shaffer, 1989" [NMRJ]. Paratypes: ♂, 4 ♀; ♂ (Figs. 9–12, 17), labelled: "Banhado, Quatro Barras, PR. 800 m. 7-2-70 V. O. Becker leg."; "Genitalia Slide By Jay Shaffer USNM 57902" [USNM]. 4 ♀, same locality data as holotype; "16. XII. 1974" J. Shaffer genitalia slide 2246 [NMRJ]; "14. I. 1975" undissected [NMRJ]; "4. II. 1975" (Figs. 4, 19, 20) USNM slide 57903 [USNM]; "25. XII. 1974" (Fig. 3) abdomen lost [USNM]. All paratypes bear the label: "Paratype *Goya simulata* Shaffer, 1989."

Discussion.—This species is very similar to *albivenella* in external characters. The most distinct difference is the almost complete lack of white marking of 3rd A of the forewing in *simulata* contrasted with a conspicuous white tracing over this vein in *albivenella.* Also, there is a conspicuous white tracing over the forewing 2nd A in *albivenella,* a marking much less prominent in 2 of the 6 *simulata* types and absent in the other 4. Lastly, the forewing ground color posterior to the cell is yellowish brown in *albivenella,* brown in *simulata* and in some specimens of the latter grayish red posterior to 2nd A.

The male genitalia of *simulata* and *albivenella* can be compared in Figs. 13 and 18 respectively. Three differences are noteworthy. In *albivenella* the medial process of the uncus is laterally and ventrally armed with a multitude of minute stout spines, and bears posterolateral expansions each terminating in a large posteriorly directed spine, the two spines essentially parallel. By contrast, this process in *simulata* is lacking in minute spines, curved along its posterior margin, and armed only with a pair of short divergent conical cusps. Secondly, the medial process of the gnathos is markedly different in the two species, cordate and keeled in *simulata,* quadrate in *albivenella.* Finally, the well developed patch of setae at the base of the valve costa in *simulata* (Fig. 13 diagonal arrow) is completely absent in *albivenella.*

The female genitalia of *simulata* differ from those presumed to be *albivenella* in the more elongate shape of the 8th segment collar, 1.7 times as long as wide in *simulata,* 1.0 times in *albivenella*; in the much longer anterior and posterior apophyses, and in the longer posterodorsal sac of the 8th segment. This comparison is based on an examination of the lectotype of *cancelliella,* a junior synonym of *albivenella.* These features distinguish *simulata* from all other known species of *Goya.*

In summary, *simulata* and *albivenella* can readily be distinguished by clear differences in the male genitalia of their holotypes and it is on these differences that the distinction between the two species presently rests. The constancy of the differences in wing pattern described above can only be evaluated when a larger series of specimens of both species becomes available for study. Likewise, a good series of specimens of *albivenella* including both sexes from one population should resolve any questions as to the identity and characteristics of females of that species.

Etymology.—The specific epithet is an adjective derived from the Latin *similis* (like) in reference to the external resemblance to *albivenella.*

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The holotype and 2 female paratypes are deposited in the National Museum, Rio de Janeiro, Brazil [NMRJ]. The male paratype and two female paratypes are in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. USA [USNM].

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# JAPANESE SAWFLIES OF THE FAMILY BLASTICOTOMIDAE (HYMENOPTERA: SYMPHYTA)

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*Abstract.*—The family Blasticotomidae of Japan is revised, and one new species, **Blasticotoma warabii** sp. nov., is described and illustrated. A key to the Japanese genera and species and illustrations of their taxonomically important characters are given. Food plants of *Runaria flavipes* are newly described.

*Key Words:* Blasticotomidae, *Blasticotoma, Runaria*

Blasticotomidae is a small family of Tenthredinoidea associated with ferns and occurs only in the Palearctic Region. Smith (1978) listed 8 world species and subspecies in three genera and Shinohara (1983) added two species from Taiwan. In Japan, the family contains four species and one subspecies of two genera, namely, *Blasticotoma atra* Zhelochovtsev, 1934, *B. nipponica* Takeuchi, 1939, *B. filiceti pacifica* Malaise, 1931, *Runaria reducta* Malaise, 1931, and *R. flavipes* Takeuchi, 1939. Recently, I had an opportunity to examine three specimens which were captured on stems of bracken fern, *Pteridium aquilium* (L.), in Hokkaido, Japan. These specimens resemble *B. nipponica* and *B. filiceti pacifica,* but they differ from *B. nipponica* by the small tooth of the claw and by the slender sawsheath, and from *B. filiceti pacifica* by the maculation of the forewing. I, therefore, believe that these specimens are new to science. In this paper, I describe and illustrate this species.

## DIAGNOSIS OF BLASTICOTOMIDAE

First discoidal cell of forewing petiolate, stigma of forewing large and nearly semicircular in shape, anal cell of forewing with an oblique crossvein (Fig. 8). Antenna with four (Fig. 6) or three segments.

## KEY TO THE JAPANESE GENERA AND SPECIES

1. Antenna with three segments, tarsal claw without inner tooth (*Runaria*) .................. 2
– Antenna with four segments, tarsal claw with inner tooth (Figs. 20–23) (*Blasticotoma*) . . . 3
2. Legs black with anterior four knees, all tibiae and tarsi yellow ............. *R. reducta* Malaise
– Legs yellow to reddish yellow, only coxae black ....................... *R. flavipes* Takeuchi
3. Female .......................... 4
– Male .................................... 7
4. Forewing entirely infuscate (Fig. 2) .......... 5
– Forewing partially infuscate (Fig. 1) ......... 6
5. Legs black with all knees, tibiae, and tarsi reddish yellow (Figs. 13 and 14); inner tibial spur of fore leg as in Figs. 18 and 19; sawsheath as in Fig. 27 ............... *B. atra* Zhelochovtsev
– Legs reddish yellow with all coxae and trochanters black; inner tibial spur of fore leg as in Fig. 17; sawsheath as in Fig. 26 . ....... ...................... *B. filiceti pacifica* Malaise
6. Claws with a large inner tooth (Fig. 21); hind leg black with hind tibia yellow to reddish yellow except for apical portion; inner tibial spur of fore leg as in Fig. 16; sawsheath as in Fig. 25; apical portion of forewing clear; lance as in Fig. 32 .............. *B. nipponica* Takeuchi
– Claws with a small inner tooth (Fig. 20); hind leg yellow to reddish yellow; inner tibial spur

Figs. 1–2. Dorsal view—1, *Blasticotoma warabii* sp. nov. 2, *Blasticotoma filiceti pacifica* Malaise. (3×)

of fore leg as in Fig. 15; sawsheath rather slender (Fig. 24); apical portion of forewing infuscate (Fig. 8); lance as in Fig. 31 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *B. warabii* sp. nov.

7. Forewing uniformly infuscate; genitalia as in Figs. 36 and 40; penis valve as in Fig. 44 . . . . . . . . . . . . . . . . . . . . . . . . *B. filiceti pacifica* Malaise
– Forewing rather clear, sometimes partially infuscate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8
8. Legs black with anterior four knees, all tibiae and tarsi reddish yellow (Figs. 11 and 12); genitalia as in Figs. 37 and 41; penis valve as in Fig. 45 . . . . . . . . . . . . . . . . . . *B. atra* Zhelochovtsev
– Anterior four legs reddish yellow with all coxae and trochanters black . . . . . . . . . . . . . . . . . . . . . . 9
9. Hind femur and apical portion of hind tibia black; genitalia as in Figs. 35 and 39; penis valve as in Fig. 43 . . . . . . *B. nipponica* Takeuchi
– Hind femur and apical portion of hind tibia reddish yellow; genitalia as in Figs. 34 and 38; penis valve as in Fig. 42 . . . . . *B. warabii* sp. nov.

### ***Blasticotoma warabii* Togashi, New Species**

Figs. 1, 3–8, 15, 20, 24, 28, 31, 34, 38, 42

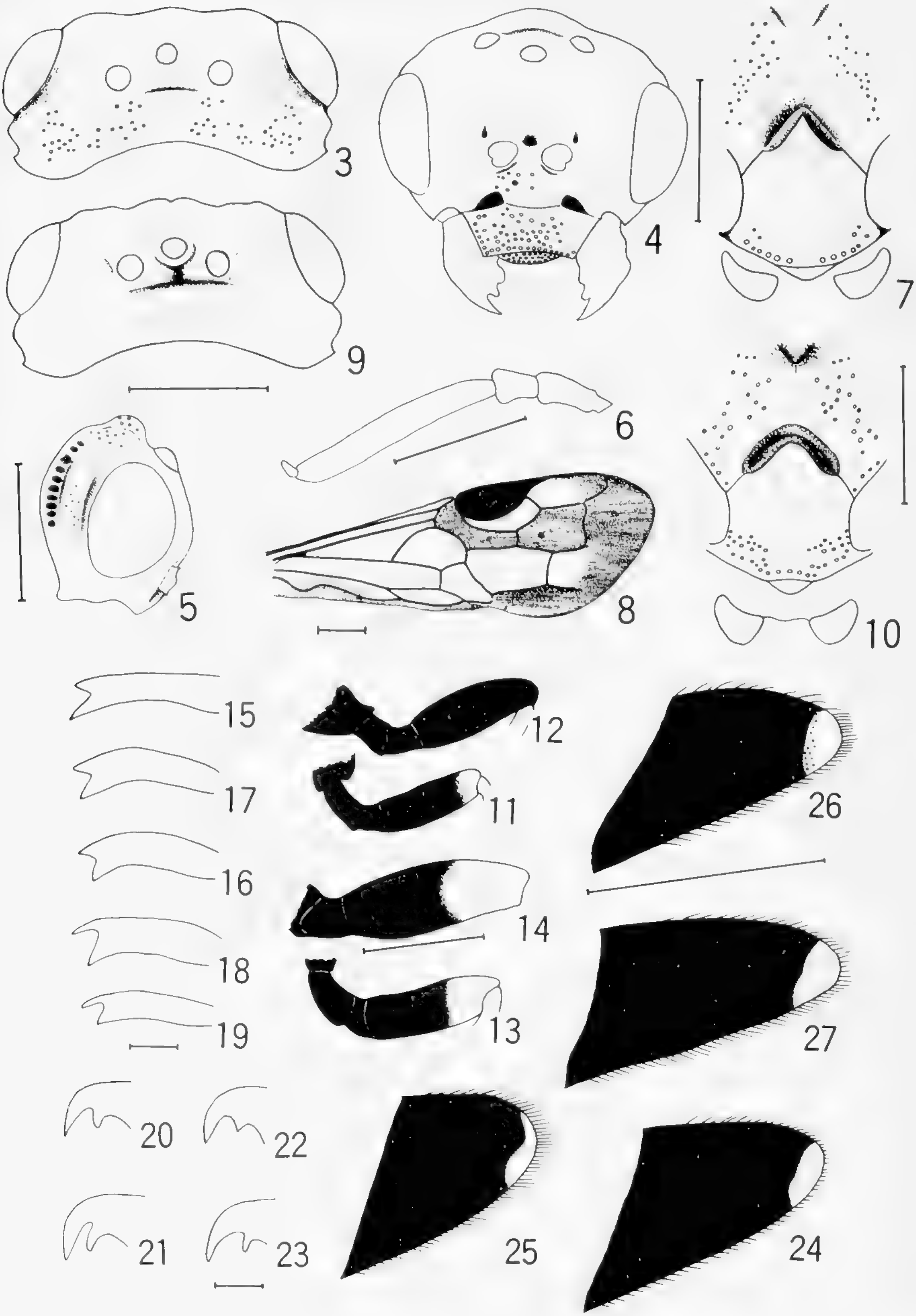
Female.—Length 9 mm. Body including antenna black, but cenchri pale white, apical half of mandible and apical portion of sawsheath reddish brown. Wings as in Fig. 8. Legs reddish yellow, with following parts black: all coxae and trochanters, and basal portion of all femora.

Head transverse, postocellar area distinctly raised; lateral and interocellar furrows nearly absent; postocellar furrow rather distinct (Fig. 3); OOL:POL:OCL = 0.7:1.0:0.8; frontal area nearly flattened; postorbital groove distinct and broad (Fig. 5); postgenal carina distinct; median fovea as in Fig. 5; lateral foveae comma-like; supraclypeal area slightly convex; clypeus nearly flattened, frontal margin nearly truncate (Fig. 4); labrum small; malar space broad; mandibles tridentate (Fig. 4); antenna as in Fig. 6.

Thorax normal; mesoscutellum as in Fig. 7. Inner tibial spur of fore leg as in Fig. 15; claw with a small inner tooth (Fig. 20). Abdomen normal; sawsheath as in Fig. 24; ratio between length of sawsheath and basal plate at about 1.0:2.1; lancet with 13 serrulae (Fig. 28); lance with 8–9 serrulae (Fig. 31).

Sculpture.—Face rather shallowly, irregularly, and reticulately sculptured; occipital margin coarsely and distinctly punctured; clypeus rather evenly, shallowly, and distinctly punctured; labrum densely punctured; pronotum shagreened, with distinct and large punctures; posterior half of mesonotal lateral lobes coarsely and distinctly punctured (Fig. 7); mesoscutellum nearly impunctate, but posterior margin with distinct punctures (Fig. 7); mesopleuron distinctly and evenly punctured; mesosternum nearly impunctate, but with some distinct punctures. Abdominal tergites shagreened, but last tergite nearly impunctate, shining.

Male.—Length 7 mm. Coloration and structures except for male genitalia as in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female. Male genitalia as in Figs. 34 and 38; penis valve as in Fig. 42.

Habitat.—Japan (Hokkaido and Honshu).

*Holotype:* Female, 13. VI. 1986, Hitsujigaoka, Sapporo, Hokkaido (Type No. 2661, deposited in the Entomological Laboratory of Kyushu University).

*Paratypes:* Two females, same date for holotype; three males, 17. V. 1968, Sasari, Kyoto Pref., T. Naito leg.

Remarks.—This new species closely resembles *B. nipponica* but it differs from the latter species by the small inner tooth of the claw (in *nipponica,* the claw has a large inner tooth, as in Fig. 32); by the shape of the apex of the inner tibial spur of the fore leg (in *nipponica,* the apex of the inner tibial spur has both furcations subequal in size as in Fig. 16); and by the characters of the lancet, lance and penis valve.

### *Blasticotoma nipponica* Takeuchi, 1939
Figs. 16, 21, 25, 29, 32, 35, 39, 43

*Blasticotoma nipponica* Takeuchi, 1939, p. 394.

Specimens examined.—Two males, 23. V. 1954, Mt. Tomuro, Kanazawa, Ishikawa Pref.; one female and one male, 10. V. 1969, Yoshioka, Kawachi-mura, foot of Mt. Hakusan, Ishikawa Pref.; one female, 12. V. 1978, Mt. Shiritaka, near Tsurugi-machi, Ishikawa Pref.; one male, 24. V. 1984, Tsurugi-machi, Ishikawa Pref.; one female, 31. V. 1987, Kinome Path, Imajo-cho, Fukui Pref.; one female, 5. VI. 1988, Mt. Rokumanbe, near Mt. Hakusan, Ishikawa Pref.

Supplementary notes.—Apex of inner tibial spur of fore leg bifurcate (Fig. 16); sawsheath rather short (Fig. 25); ratio between length of sawsheath and basal plate at about 1.0:2.1; lancet with 13 serrulae (Fig. 29); lance with 11 serrulae (Fig. 32); male genitalia as in Figs. 35 and 39; penis valve as in Fig. 43.

### *Blasticotoma filiceti pacifica* Malaise, 1931
Figs. 2, 9–10, 17, 22, 26, 30, 33, 36, 40, 44

*Blasticotoma filiceti pacifica* Malaise, 1931, p. 212.

Specimens examined.—(Hokkaido) One male, 10. VII. 1967, Aizankei, foot of Mt. Taisetsu, T. Naito leg.; two females, 23. VII. 1969, Mt. Rausu, Shiretoko Peninsula, T. Naito leg.; one female, 19. VII. 1987, Aizankei, foot of Mt. Taisetsu, T. Naito leg. (Honshu) One female, 17. VI. 1968, Sasari, Kyoto Pref., T. Naito leg.; two females, 29. VI. 1972, Mt. Shiritaka, near Tsurugi-machi, Ishikawa Pref.; one female, 7. V. 1972, Fukase, Okuchi-mura, foot of Mt. Hakusan, Ishikawa Pref.; one female, 9. V. 1984, Tsurugi-machi, Ishikawa Pref.

Supplementary notes.—Posttergite reddish brown to dark brown; apex of inner tibial spur of fore leg bifurcate (Fig. 17); sawsheath as in Fig. 26; ratio between length of sawsheath and basal plate at about 1.0:2.3; lancet with 12 serrulae (Fig. 30); lance with 8–9 serrulae (Fig. 33); male genitalia as in Figs. 36 and 40; penis valve as in Fig. 44.

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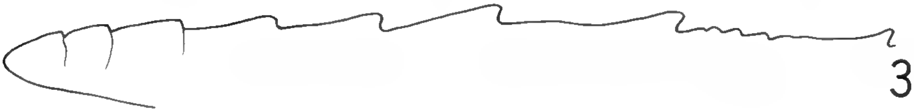
Figs. 3–27. Figs. 3–8. *Blasticotoma warabii* sp. nov.—3, head, dorsal view; 4, do, frontal view; 5, do, profile; 6, antenna; 7, mesoscutellum and cenchri; 8, forewing. (Scale: 1 mm.) Figs. 9–10. *B. filiceti pacifica* Malaise—9, head, dorsal view; 10, mesoscutellum and cenchri. (Scale: 1 mm.) Figs. 11–14. Fore and hind legs, except for tibiae and tarsi, of *B. atra* Zhelochovtsev—11, fore leg of male; 12, hind leg of male; 13, fore leg of female; 14, hind leg of female. (Scale: 1 mm.) Figs. 15–19. Inner tibial spur of fore leg—15, *B. warabii*; 16, *B. nipponica*; 17, *B. filiceti pacifica*; 18 and 19, *B. atra*. (Scale: 0.1 mm.) Figs. 20–23. Hind tarsal claw—20, *B. warabii*; 21, *B. nipponica*; 22, *B. filiceti pacifica*; 23, *B. atra*. (Scale: 0.1 mm.) Figs. 24–27. Sawsheath, lateral view—24, *B. warabii*; 25, *B. nipponica*; 26, *B. filiceti pacifica*; 27, *B. atra*. (Scale: 1 mm.)



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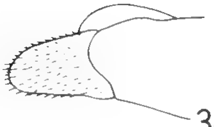

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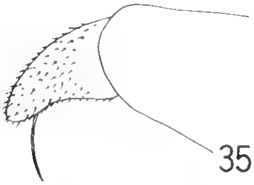

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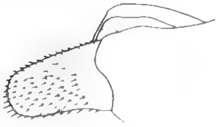

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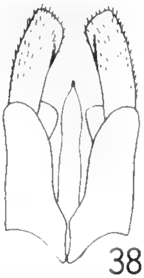

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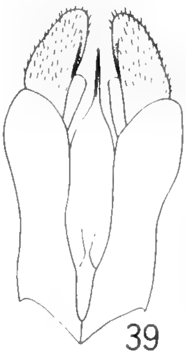

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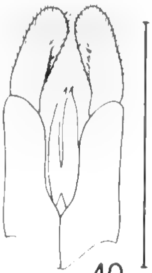

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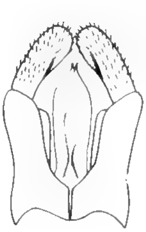

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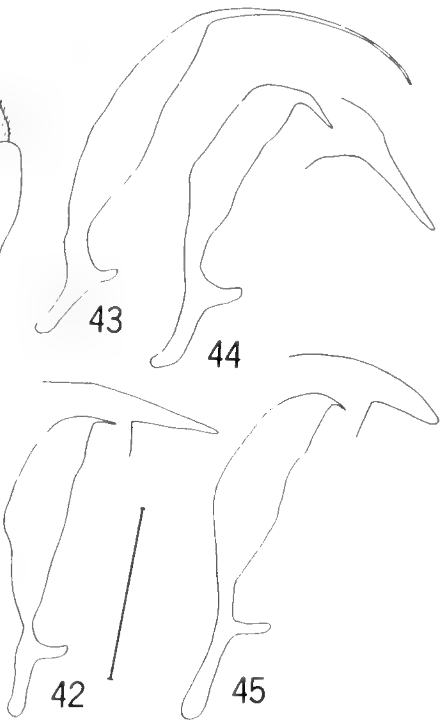

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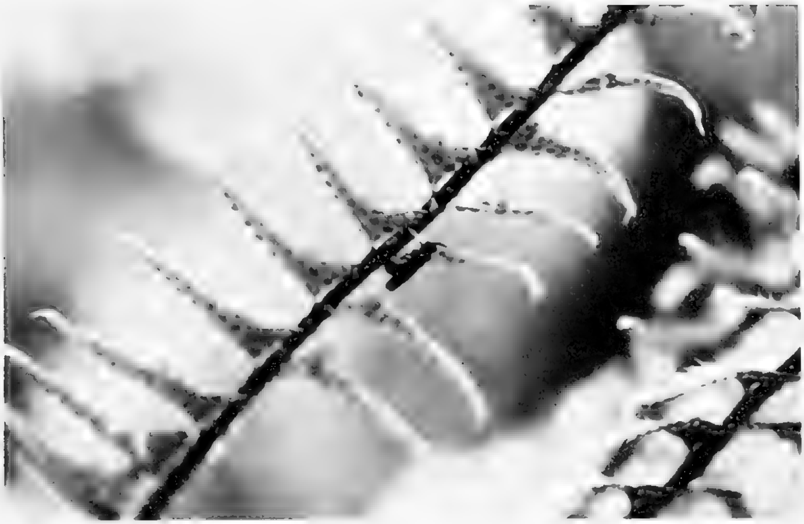

Fig. 46. Oviposition of *Runaria flavipes,* food plant: *Polystichum tripteron.* (1×)

### *Blasticotoma atra* Zhelochovtsev, 1934

Figs. 11–14, 18–19, 23, 27, 37, 41, 45

*Blasticotoma atra* Zhelochovtsev, 1934, p. 154.

Specimens examined.—(Hokkaido) One female, 23. VII. 1969, Mt. Rausu, Shiretoko Peninsula, T. Naito leg.; one female, 19. VII. 1987, Aizankei, foot of Mt. Taisetsu, T. Naito leg. (Honshu) Two males, 4. VII. 1964, Karasawa, foot of Mt. Hodaka, Nagano Pref., T. Naito leg.; one male, 11. VI. 1968, Uchinikaya, Ina, Nagano Pref., T. Naito leg.

Supplementary notes.—Legs dark brown to black, but in female, all knees, tibiae and tarsi reddish yellow, and in male, anterior four knees, all tibiae and tarsi reddish yellow (Figs. 11–14); inner tibial spur of fore leg as in Figs. 18 and 19; male genitalia as in Figs. 35 and 39; penis valve as in Fig. 45.

Remarks.—The structure of the lancet and lance of this species are similar to those of *B. filiceti pacifica,* but the shape of the inner tibial spur of the fore leg and male genitalia and penis valve show differences between these two species.

### *Runaria reducta* Malaise, 1931

*Runaria reducta* Malaise, 1931, p. 213.

Specimens examined.—One female and one male, 10. V. 1969, Yoshioka, Kawachimura, foot of Mt. Hakusan, Ishikawa Pref.; one male, 25. V. 1972, Mt. Shibatake, Niigata Pref., K. Baba leg.; three females, Mt. Shiritaka, near Tsurugi-machi, Ishikawa Pref.; two males, 13. VI. 1986, Hitsujigaoka, Sapporo, Hokkaido.

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Figs. 28–45. Figs. 28–30. Lancet—28, *B. warabii*; 29, *B. nipponica*; 30, *B. filiceti pacifica.* Figs. 31–33. Lance—31, *B. warabii*; 32, *B. nipponica*; 33, *B. filiceti pacifica.* Figs. 34–37. Male genitalia, lateral view—34, *B. warabii*; 35, *B. nipponica*; 36, *B. filiceti pacifica*; 37, *B. atra.* (Scale: 1 mm.) Figs. 38–41. Male genitalia, dorsal view—38, *B. warabii*; 39, *B. nipponica*; 40, *B. filiceti pacifica*; 41, *B. atra.* (Scale: 1 mm.) Figs. 42–45. Penis valve—42, *B. warabii*; 43, *B. nipponica*; 44, *B. filiceti pacifica*; 45, *B. atra.* (Scale: 0.5 mm.)

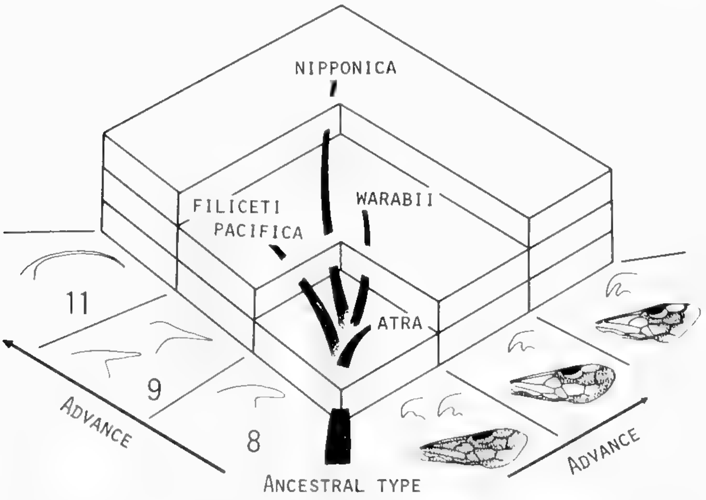

Fig. 47. Pictorial phylogeny of the genus *Blasticotoma* on the basis of the shapes of the external characters of the adult.

### *Runaria flavipes* Takeuchi, 1939
### Fig. 46

*Runaria flavipes* Takeuchi, 1939, p. 396.

Specimens examined.—Three females and six males, 20–24. V. 1984, Mt. Shiritaka, near Tsurugi-machi, Ishikawa Pref.; one female, 5. V. 1987, Mt. Shiritaka, near Tsurugi-machi, Ishikawa Pref.; one female, 5. V. 1988, Tsurugi-machi, Ishikawa Pref.

Supplementary note.—In 1987, I observed a female of this species ovipositing on the stem of *Polystichum tripteron* (Fig. 46); thus this must be the host plant.

## Phylogenetic relationship of *Blasticotoma* occurring in Japan

The comparative morphology of the male genitalia indicates that *Blasticotoma* can be clearly divided into two groups: *nipponica*-group and *filiceti*-group. Each group has a definite character of the penis valve as shown in Figs. 42–45. The penis valve of *filiceti*-group has a short projection at the end of the valviceps (Figs. 42, 44, and 45), but that of *nipponica*-group has an elongate projection (Fig. 43). The number of the serrula of the lance in the female also shows the corresponding distinction. Also, the shape of the inner tooth of the tarsal claw is different from species to species (Figs 20–23). According to the shape of the inner tooth of the tarsal claw, *filiceti*-group is divided into two subgroups, *filiceti*-subgroup and *warabii*-subgroup (Fig. 47). I also observed the differentiational tendency of wing maculation (Fig. 47). The phylogenetic relationship of *Blasticotoma* is illustrated in Fig. 47, which is based on the above-mentioned external characters.

## ACKNOWLEDGMENTS

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PROC. ENTOMOL. SOC. WASH.
91(3), 1989, pp. 414–420

# TYPE MATERIAL OF TWO AFRICAN SPECIES OF *HERPETOGRAMMA* AND ONE OF *PLEUROPTYA* (LEPIDOPTERA: CRAMBIDAE: PYRAUSTINAE)

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*Abstract.* — Lectotypes for the African pyraustine species *Botys mutualis* Zeller and *Botys aegrotalis* Zeller (Lepidoptera: Crambidae: Pyraustinae) are designated, illustrated, and characterized, and the species transferred to *Herpetogramma* and *Pleuroptya*, respectively (new combinations). The holotype of the related *Botys verminalis* Guenée is also illustrated, and characterized, and the species transferred to *Herpetogramma* (new combination). The 3 species are considered distinct from one another and from the American *Herpetogramma bipunctalis* (Fabricius) with which they were synonymized by Hampson, 1899.

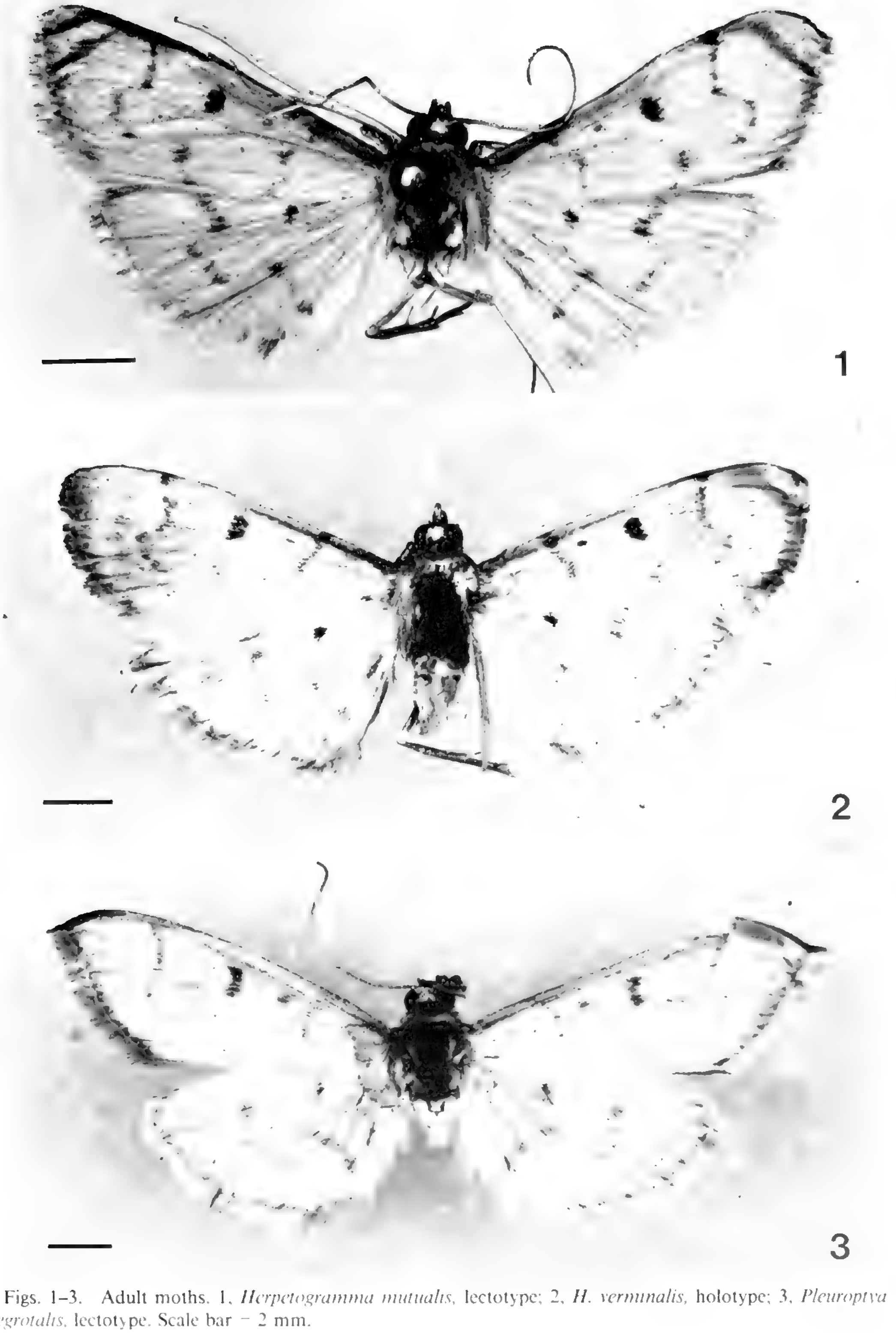
*Key Words:* African Pyraustinae, Pyralidae, lectotypes, Zeller types, *Herpetogramma bipunctalis, Herpetogramma mutualis, Herpetogramma verminalis, Pleuroptya aegrotalis*

This paper grew out of an attempt to identify two sibling species of the pyraustine genus *Herpetogramma* for a faunal study on the Crambidae of Aldabra Atoll (in prep.). We had narrowed our search to three externally similar African species: *Botys aegrotalis* Zeller, *B. mutualis* Zeller, and *B. verminalis* Guenée. All three appeared to be very close to the two Aldabra species, and in fact were among 18 names synonymized by Hampson (1899: 204) under *Pachyzancla bipunctalis* (Fabricius), a pest species commonly known as the southern beet webworm. While it is beyond the scope of this paper to review that synonymy, most of those 18 are deserving of separate specific status, with *bipunctalis* itself being restricted to the Western Hemisphere. Our purposes here are to illustrate types in order to facilitate identification, to provide proper generic assignment, and to designate lectotypes so as to promote stability for the names.

We follow Minet's (1981) separation of the traditional family Pyralidae into Crambidae and Pyralidae, this essentially along the same lines as the division of the Pyralidae into the Series Crambiformes and Pyraliformes in the Moths of North America (MONA) volumes (Munroe *in* Dominick 1972).

Through the courtesy of Mr. Bert Gustafsson of the Swedish Natural History Museum [NHRM] we were able to borrow for dissection two specimens placed under *aegrotalis,* there being no material found there under *mutualis.* Each specimen bore a "Caffraria" label (Fig. 4) typical of the material Zeller (1852) examined in his study, and so could be a type. There is also Zeller material labeled as *aegrotalis* and *mutualis* in the collection of the British Museum (Natural History) [BMNH].

After a more detailed examination of the two Stockholm specimens it became clear that they were not conspecific and that nei-



Figs. 1–3. Adult moths. 1, *Herpetogramma mutualis*, lectotype; 2, *H. verminalis*, holotype; 3, *Pleuroptya aegrotalis*, lectotype. Scale bar = 2 mm.

Figs. 4–6. Specimen labels. 4, *Herpetogramma mutualis,* lectotype (1.0×); 5, *H. verminalis,* holotype (1.6×); 6, *Pleuroptya aegrotalis,* lectotype (1.6×).

ther matched Zeller's description of *aegrotalis.* However, one of these (Figs. 1, 4) was a better match for *mutualis* than the specimen under that name in the British Museum, and so we designate this Stockholm specimen as the lectotype. The other Stockholm specimen (J. C. Shaffer ♂ genitalia slide no. 1944) is conspecific with an Aldabran species which we intend to describe as new.

### *Herpetogramma mutualis* (Zeller), New Combination, Revised Status

Figs. 1, 4, 7–10

*Botys mutualis* Zeller, 1852: 40–41.

*Pachyzancla mutualis* (Zeller). Hampson, 1899: 204. As synonym of *P. bipunctalis* (Fabricius).

Lectotype, hereby designated, labeled (Fig. 4): "Caffraria"; "Riksmuseum Stockholm"; "♂ genitalia on slide 1943 J. C. Shaffer"; "Lectotype *Botys mutualis* by J. Shaffer & E. Munroe, 1989." [NHRM]. Zeller indicated that he had both sexes represented, but did not specify the number of specimens. As we have not discovered any other specimens conspecific with the lectotype in material known to have been studied by Zeller, we conclude that either his type series was of mixed composition or some of it has been lost.

*Type locality:* South Africa. Zeller (p. 41) cites the type locality as: "Habitat in tractibus fluviorum Limpoponis et Gariepis." This is roughly the region of the Transvaal and Orange Free State. (See Shaffer & Munroe, 1989: 272.)

The following points of agreement between Zeller's description and the lectotype (Fig. 1) are particularly noteworthy (italics text adapted rather freely from Zeller's description). Comparisons of the same characters are made with the BMNH specimen under *mutualis,* and with the BMNH lectotype (designated below) of *aegrotalis* (Fig. 3). The purpose of the comparisons with the BMNH specimens is to demonstrate clearly that neither of them matches Zeller's description of *mutualis.*

a. *Wing lines nodulose*—This is clearly seen in the postmedial line of the *mutualis* lectotype. In the BMNH specimen under *mutualis* the postmedial line is interrupted, but not nodular, and in the *aegrotalis* lectotype it is continuous and clearly not nodular.

b. *Posterior sinus* (outward bulge) *of postmedial line less rectilinear than in aegrotalis*—The upper and lower outer angles of this bulge form right angles in the *aegrotalis* lectotype and approximate this in the BMNH specimen under *mutualis,* but are rounded in the lectotype of *mutualis.*

c. *Small spot or thickened dot on transverse vein*—This is a reference to the discal spot, elliptical in both the *mutualis* lectotype and the BMNH specimen under *mutualis,* but conspicuously different in *aegrotalis* with its lunate discal spot. This is one of the most obvious features separating *mutualis* and *aegrotalis.*

d. *Orbicular spot halfway between antemedial line and discal spot*—This feature fits the lectotype, but in the BMNH specimen under *mutualis* and in *aegrotalis* the orbicular spot is at approximately ⅖ the distance from the antemedial line to the discal spot.

e. *Postmedial line thickened at costa*—This feature is evident in the *mutualis* lectotype, but not in the BMNH specimen under *mutualis* where the line stops short of the costa, nor in the *aegrotalis* lectotype where the line reaches the costa but is not thickened there.

f. *Postmedial line nearly straight above sinus*—The *mutualis* lectotype and the BMNH specimen under *mutualis* agree in this feature, but in the *aegrotalis* lectotype this portion of the line is concave.

g. *Hindwing discal spot round*—The *mutualis* lectotype and the BMNH specimen under *mutualis* agree in this, but in the *aegrotalis* lectotype the discal spot is in the form of a short bar.

h. *Hindwing with outward sinus of postmedial line straight*—The *mutualis* lectotype agrees with this and the BMNH specimen under *mutualis* is very close, but in *aegrotalis* the upper side is curved.

In the male genitalia of the lectotype (Figs. 7–10) the uncus is narrowly triangular with the sides less divergent on the distal third and the apex narrowly rounded; the distal third is moderately setose with the setae extending toward the base along the sides, but not quite reaching the base. The inner margin of the sacculus bears a small, low, moundlike setose projection (Fig. 8) on its inner margin, but no clasper is present. Two kinds of armature occur on the vesica; just posterior to the center of the aedeagus is seen an irregular platelike sclerite presenting a short digitate profile, ill defined anteriorly, rounded posteriorly, tapering, acute at its apex. This feature did not photograph well, but is outlined in black ink in Fig. 9. On the distal fourth of the aedeagus the uneverted vesica exhibits a 'bottle-brush' arrangement (Fig. 10) of what appears to be a very large number of slender apparently spatulate setae densely arranged around a central axis.

## ***Herpetogramma verminalis*** **(Guenée), NEW COMBINATION, Revised Status**

Figs. 2, 5, 14–16

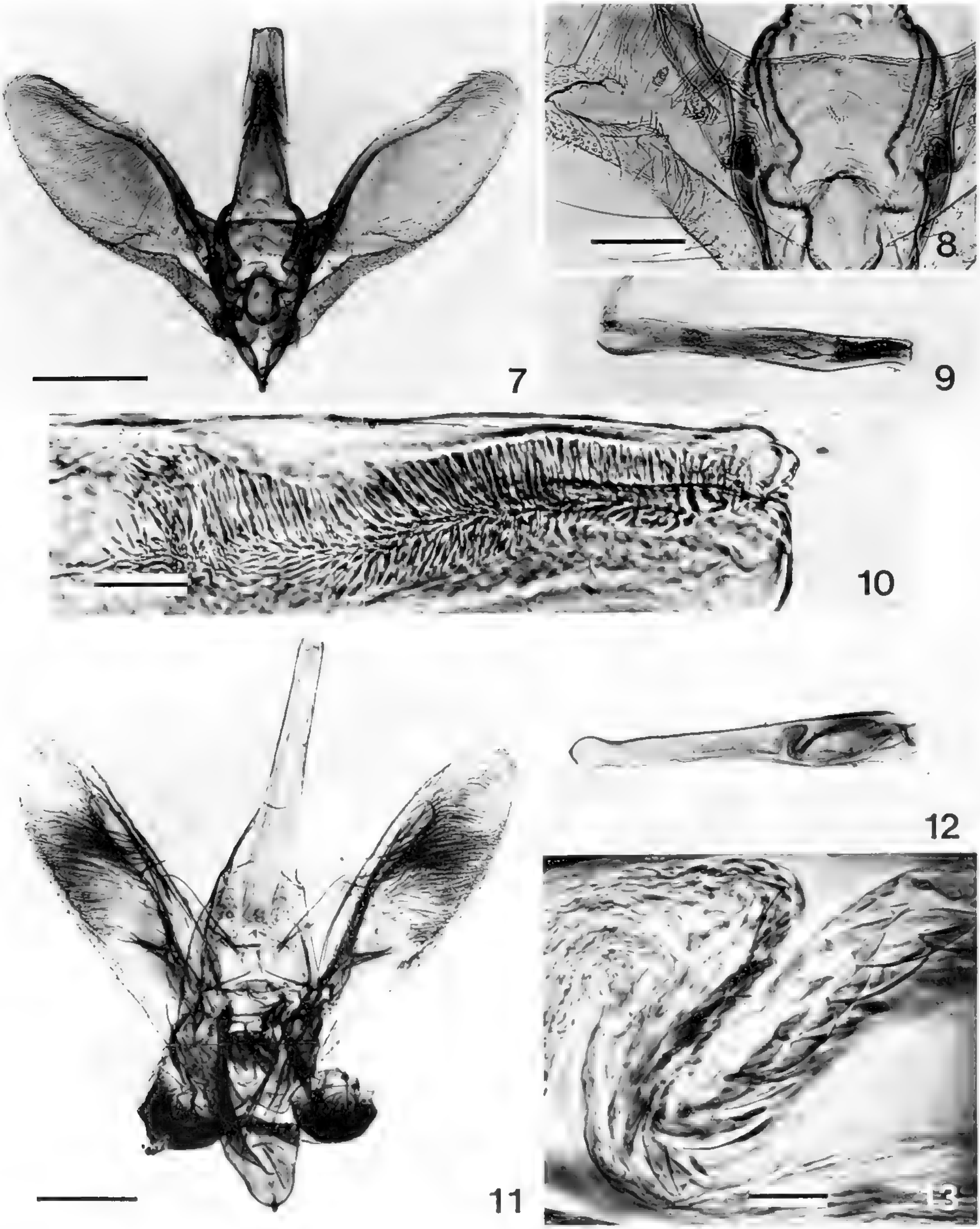
*Botys verminalis* Guenée, 1854: 348.

*Pachyzancla verminalis* (Guenée). Hampson, 1899: 204. As synonym of *P. bipunctalis* (Fabricius).

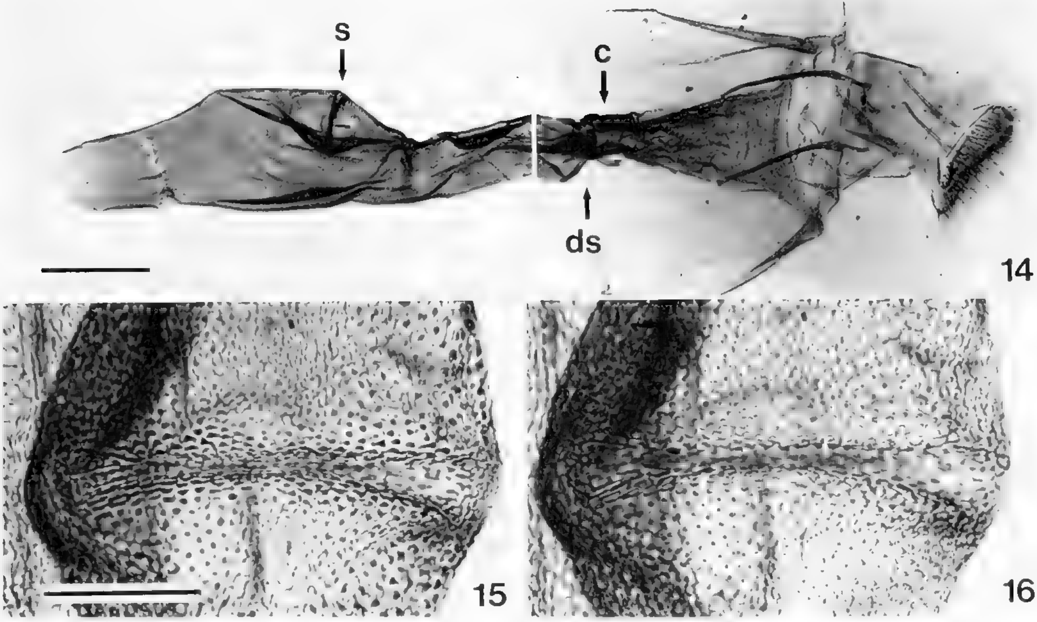
Holotype, female, Sierra Leone, labelled: "Holo-type"; "Verminalis Gn. Sierra Leone"; "Paravicini Coll. B.M. 1937-383."; "Holotype"; "♀ Pyralidae Brit. Mus. Slide No. 14576" [BMNH].

We illustrate the holotype (Fig. 2) to show the wing pattern, which is different from both those of *mutualis* and *aegrotalis,* and we figure the genitalia, although Michael Shaffer reports that the abdomen appeared to have been glued on, so that there is some doubt as to its correct association. Nonetheless, the wing maculation is clearly that of a *Herpetogramma,* and characters of the genitalia agree well with those of known species of *Herpetogramma.* Further study of the genus may well show that the genitalia figured are indeed those of *verminalis.*

Female genitalia (Figs. 14–16).—Posterior apophysis straight, slender; anterior apophysis about 2× as long as posterior, broadened and distinctly downcurved near base. Anterior half of eighth-segment collar nude, posterior half bearing numerous fine setae (on this specimen about 36 on right side, about 28 on left side, about 16 ventrally). Ostial chamber funnel shaped; anterior half with numerous folds bearing minute subovate scales, each several micrometers wide (these best seen on edge, and then with difficulty). Ductus bursae broadly joining corpus bursae; posterior end forming smooth, unarmed, well sclerotized collar (Fig. 14, c) nearly 2× as wide as long; anterior and adjacent to this collar the membrane armed with numerous minute sharp spines, these continued anteriorly,



Figs. 7–13. Male genitalia. 7, *Herpetogramma mutualis,* lectotype; 8, enlarged to show basal detail of left valve; 9, aedeagus; 10, distal end of aedeagus, enlarged. 11, *Pleuroptya aegrotalis,* lectotype; 12, aedeagus; 13, detail of vesica showing cornuti. Scale bar = 0.50 mm (Figs. 7 & 9, 11 & 12); 0.20 mm (Fig. 8); 0.05 mm (Figs. 10, 13).



Figs. 14–16. *Herpetogramma verminalis*, holotype. Fig. 14, female genitalia (c = sclerotized collar of ductus bursae, ds = ductus seminalis, s = signum); Figs. 15–16, signum, enlarged, two focal levels, each rotated 90° clockwise relative to Fig. 14. Scale bar = 0.50 mm (Fig. 14), 0.10 mm (Figs. 15–16).

gradually becoming shorter, broader, and forming triangular denticles which extend onto corpus bursae to a short distance beyond signum (many are seen in Figs 15, 16). Corpus bursae with midregion bearing weakly developed transverse signum about half as long as corpus bursae width (Fig. 14, s); at high magnification (Figs. 15, 16) signum seen as a deep narrow groove armed with minute triangular denticles on its margin and sides, and with longer spatulate scales at its bottom and ends. Ductus seminalis (Fig. 14, ds) from ductus bursae just anterior to sclerotized collar; broadened and funnel shaped at origin.

### ***Pleuroptya aegrotalis* (Zeller), New Combination, Revised Status**

Figs. 3, 6, 11–13

*Botys aegrotalis* Zeller, 1852: 38–39.

*Pachyzancla aegrotalis* (Zeller). Hampson, 1899: 204. As synonym of *P. bipunctalis* (Fabricius).

*Psara aegrotalis* (Zeller). Klima, 1939: 384. As distinct species.

Lectotype, hereby designated, labeled (Fig. 5): "Type"; "Botys aegrotalis Z. Caffr. 39. Led. 85. Caffraria." [handwritten]; "Zell. Coll. 1884."; "♂ Pyralidae Brit. Mus. Slide No. 17755"; "Lectotype by J. Shaffer & E. Munroe, 1989." The original description was based on the male sex. The number of specimens was unspecified and we have not discovered additional Zeller material of this species.

*Type locality:* South Africa. Zeller (p. 39) cites the type locality as: "Habitat in tractibus fluviorum Limpoponis et Gariepis." This is roughly the region of the Transvaal and Orange Free State. (See Shaffer & Munroe, 1989: 272.)

As discussed above neither of the males under *aegrotalis* in the Stockholm museum matches the original description. We have chosen the single male in the British Museum as the lectotype as it is a good match for Zeller's description, the following points of agreement being particularly noteworthy (Fig 3):

a. The forewing apex is acuminate.

b. The forewing termen (outer margin) is oblique and slightly convex posteriorly.

c. The discocellular spot is a distinct lunule. This is one of the most obvious features of *aegrotalis.*

d. The outward sinus of the postmedial line forms nearly a right angle at both top and bottom ends.

e. The hindwing discocellular is marked by a short bar rather than by a spot.

We also note that in contrast to *mutualis* the postmedial line is not thickened at the apex and is not nodular.

The male genitalia of the lectotype (Figs. 11–13) show that, despite its resemblance in wing pattern to certain species of *Herpetogramma, aegrotalis* does not belong to that genus at all, but is a typical member of the genus *Pleuroptya* Meyrick, 1890, where we transfer it as a new combination (see above). Among the distinctive features are the short, distally truncate and medially slightly excavated uncus, without specialized dorsal scaling or spines, the narrow, bridgelike gnathos, the broad, medially complete transtilla, the prominent saccus, the large saclike coremata, and the ventrodistally oblique, clavate clasper, arising subbasally from the subcostal ridge of the valve. The vesica, withdrawn in the holotype within the clavate aedeagus, is densely set with small but strong, triangular denticles (Fig. 13).

Several probably related species occur in Africa, but we have not so far detected any junior synonym that needs to be supplanted by *aegrotalis.*

## ACKNOWLEDGMENTS

We thank Mr. Bert Gustafsson of the Naturhistoriska Riksmuseet, Stockholm for the loan of Zeller material and Mr. Michael Shaffer of the British Museum (Natural History) for the loan of genitalia slides and photographs of specimens and labels reproduced herein (Figs. 2, 3, 5, 6). We also appreciate the helpful comments of two anonymous reviewers.

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# A NEW SPECIES OF *RHEUMATOBATES* BERGROTH FROM ECUADOR AND DISTRIBUTION OF THE GENUS (HETEROPTERA: GERRIDAE)

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*Abstract.*—***Rheumatobates peculiaris,*** n. sp., is described from Ecuador and compared to other species of the genus; distinctive characters are illustrated by line drawings. Additional distributional data, mainly from Mexico and Mesoamerica, are given for other species of the genus.

*Key Words:* Heteroptera, Gerridae, New World, *Rheumatobates peculiaris* n. sp. distribution

Spangler, Froeschner, and Polhemus (1985) provided a checklist of the species and subspecies of *Rheumatobates* Bergroth, a euryhaline genus restricted to the New World. They recognized 30 species and 3 subspecies. Polhemus and Manzano (in press) add a new species from marine habitats in Colombia and Ecuador and report distributions of the marine species of the eastern tropical Pacific. In this paper we add another new species, *Rheumatobates peculiaris,* and report distributions of a number of species, based mainly on material in the Polhemus collection.

## **Rheumatobates peculiaris,** NEW SPECIES

Figs. 1–5

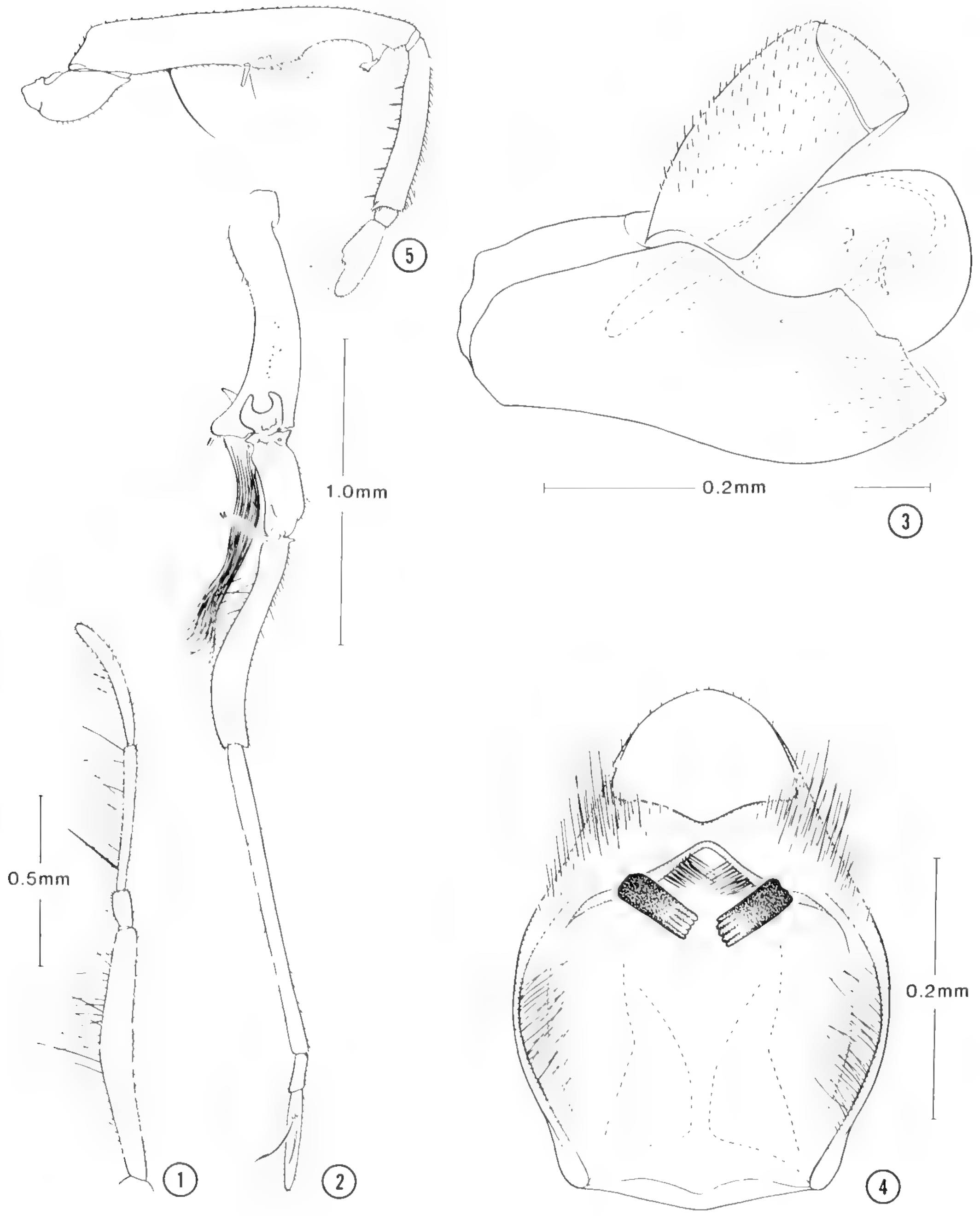
Material examined.—Holotype, apterous male; and apterous allotype: ECUADOR: LOS RIOS: Babahoyo (20 Km N.), 22 June 1975, A. Langley, J. Cohen and P. Monnig, Ecuador-Peace Corps-Smithsonian Institution Aquatic Insect Survey (USNM). Paratypes: Same data as holotype, 4 apterous males, 19 apterous females, 3 alate females, 35 nymphs (USNM, JTPC).

Etymology.—The name *peculiaris* (Latin) means strange, new and refers to the oddity of the male.

Distribution.—Ecuador.

Diagnosis.—*Rheumatobates peculiaris,* new species, vaguely resembles *Rheumatobates klagei* Schroeder but the shape of the male first antennal segment, shape and armature of the fore and hind legs, and male genitalia are unique and diagnostic. The very long, highly modified coxae separate this species from any other known species of the genus.

Description.—Length, apterous male, 2.4 mm; apterous female, 2.9 mm. Ground color of apterous male deep brown; anteromedial part of pronotum, broad ovate patch on mesonotum, entire sternum except basal abdominal segments, pleura, basal ⅘ of antennal segment 1, basal ⅔ of fore femur, coxae, most of abdominal segment VIII yellowish to leucine. Color of apterous female similar to male except with more extensive light markings as follows: antennal segment 1 and basal ⅔ of segment 3, fore femur except distal ⅒, fore tibia medially, mid and



Figs. 1–5. *Rheumatobates peculiaris* Polhemus and Spangler, new species. 1, Antenna. 2, Posterior leg. 3, Genital segments. 4, Abdominal ventrite IX. 5, Fore leg.

hind femora basally, abdominal tergites medially yellowish.

Antennae, fore legs, hind legs of male modified (Figs. 1, 2, 5). Antennal formula I–IV: male, 0.79 mm; 0.14 mm; 0.47 mm; 0.40 mm; female, 0.40 mm; 0.11 mm; 0.40 mm; 0.36 mm. Male antennae with stiff setae and bristles (Fig. 1); segment 1 slightly bowed, widest medially, with stiff setae directed mostly laterally; segments II and III straight, with various bristles and setae directed mainly ventrally but at various angles; segment IV curved, with short ventrally directed setae.

Head of male short (0.47 mm), broad (0.54 mm across antennal tubercles); equally short (0.47 mm) but narrower (0.47 mm) in female; with two long curved ocular setae. Male genital segments strongly modified; genital segment II strongly excavate beneath, with 2 (1 + 1) anteromedially directed structures apparently composed of stiff setae (Figs. 3, 4). Connexiva of male narrow; broader and flatter in female. Male fore femur modified, irregularly set with spines and bristles along posterior margin; fore tibia set with stout setae (Fig. 5). Female fore femur set with slender setae beneath; fore tibia with three long setae, two stout and one slender, and many short appressed setae. Male middle femur set along entire length with semirecumbent spines on inner side and medium length decumbent setae along outer side, with a dorsal row of about 17 long decumbent setae on distal third. Male hind coxae very long (0.68 mm), subequal to hind femur (0.76 mm), carinate dorsally, excavate laterally, strongly modified with a distal brush of posteriorly directed setae (Fig. 2); trochanter long (0.18 mm), with a medially directed spine-like process composed of stiff setae (Fig. 2). Female middle and hind femora unarmed. Male and female fore claws long, slender, similar.

Length (in mm) of legs of allotype:

| | *Femur* | *Tibia* | *Tarsal 1* | *Tarsal 2* |
|---|---|---|---|---|
| Anterior | 0.79 | 0.47 | 0.07 | 0.22 |
| Middle | 2.23 | 2.23 | 1.15 | 0.43 |
| Posterior | 1.29 | 1.01 | 0.181 | 0.32 |

Habitat.—The habitat of this species is unknown.

Distribution.—The following distributional notes were derived mainly from data with specimens in the Polhemus collection (JTPC). The CL numbers refer to detailed ecological notes made by JTP and coworkers during 25 years of collecting in Mexico and Mesoamerica. The bound journals are in the Polhemus library. Abbreviations are given only for collections other than JTPC. The names of collectors D. A., J. T., and M. S. Polhemus are abbreviated DAP, JTP, and MSP respectively. Major additions to the distributions given by Spangler, Froeschner, and Polhemus (1985) are preceded by an asterisk. Two papers not cited in the checklist by Spangler, Froeschner, and Polhemus (1985) provide additional distributional records; Drake and Hottes (1951) record *R. bonariensis* (Berg) from *Bolivia, *Paraguay, *Uruguay as well as those localities discussed below; Nieser (1970) recorded *R. crassifemur esakii* Schroeder (1931) from *Suriname, *R. klagei* Schroeder (1931) from *Peru, and *R. trinitatis* (China 1943), from *Suriname.

### *Rheumatobates bergrothi* Meinert, 1895

This species was originally described from Grenada. Drake and Hottes (1951) list it also from *Panama and the Virgin Islands. Hungerford (1954) added Venezuela, and Spangler, Froeschner, and Polhemus (1985) listed El Salvador and Honduras without definite locality data. We have the following additional records from Mesoamerica.

EL SALVADOR: 13 mi. NW of Amatillo, CL 1259, 22 Dec. 1969, JTP.

HONDURAS: 16 mi. S. San Lorenzo, CL 1310, 9 Jan. 1970, JTP; 17 mi. E. of Jicaro Galan, CL 1311, 9 Jan. 1970, JTP.

*NICARAGUA: near Lake Nicaragua, CL 1308, 8 Jan. 1970, JTP.

PANAMA: San Carlos, CL 1290, 1 Jan. 1970, JTP; E. of Panama City, CL 1295, 2 Jan. 1970, JTP.

### *Rheumatobates citatus* Drake & Hottes, 1951

This species was originally described from the state of Oaxaca, Mexico, and is also listed from the adjacent states of Chiapas and Guerrero (Hungerford 1954). All three of those localities are close to the Pacific coast, but we now have specimens from an inland locality in Morelos, dispelling any notion that this species is restricted to coastal habitats. We have the following records from Mexico and Mesoamerica.

*GUATEMALA: E. of Puerto San José, CL 1251, 20 Dec. 1969, JTP.

MEXICO: MORELOS: 20 mi. S. of Cuernavaca, CL 1047, 27 Apr. 1964, JTP & MSP; OAXACA: Tequisistlan, CL 1066, 30 Apr. 1964, JTP & MSP; E. of Tehuantepec, CL 1067, 30 Apr. 1964, JTP & MSP.

### *Rheumatobates clanis* Drake & Harris, 1932

Hussey (1955) reported this marine species as new for the United States, citing Herring's collections at Bayport, Florida, in November 1947. Herring (1958) later hypothesized that its presence there was the result of hurricane transport, and questioned whether breeding populations were established in the United States. In the Polhemus collection we have specimens collected at Pine Island (a few miles north of Bayport) by H. C. Chapman in November 1952, indicating a long term presence on the Florida west coast. In both March and August, 1988, D. A. Polhemus (personal communication) found a large and apparently well-established breeding population on brackish water near Everglades City, Florida, establishing this species as a permanent part of the fauna of the United States. We have the following records from the Caribbean and Mesoamerica.

GUATEMALA: Santo Tomas de Costilla (east coast), CL 1320, 11 Jan. 1970, JTP.

JAMAICA: St. James Greenwood, at beach, 14 Mar. 1970, C. E. Aarons; Trelawny, Martha Brae River, nr. Falmouth, 14 Mar. 1970, C. E. Aarons.

### *Rheumatobates crassifemur crassifemur* Esaki, 1926

The records from *Bolivia given by Hungerford (1954) were overlooked by Spangler, Froeschner, and Polhemus (1985).

### *Rheumatobates creaseri* Hungerford, 1936

This species was originally described from a cenote in Yucatan, Mexico, and is additionally known from Guerrero (Hungerford 1954). We have records from both coasts of Mexico.

MEXICO: *NAYARIT: San Blas, lower reaches of a spring fed river, along mangroves, CL 1208, 3 June 1966, JTP; *VERACRUZ: Rio Blanco, La Tinaja, CL 504, 4 Jan. 1971, JTP & MSP.

### *Rheumatobates drakei* Hungerford, 1954

There are specimens with the following data from Suriname and Peru in the Snow Entomological Museum that were apparently overlooked by Professor Hungerford when he described this species.

PERU: HUANUCO: Loc. Shapajilla Jungle, 630 m, No. 3837, 26 July 1938, F. Woytkowski (SEMC).

SURINAME: "Dutch Guiana," upper right Coppename River, 5e kamp, Sept. 1943, D. C. Geijskes (SEMC).

### *Rheumatobates hungerfordi* Wiley, 1923

In Hungerford's (1954) monograph, he gives a Utah locality for this species as "Emery Co., Utah, Aug. 2, 1922, Mrs. Grace Olive Wiley." One of us (JTP) has collected on the Colorado River in Grand County, Utah, and the Green River in adjacent Emery County, Utah, without finding this species, and has long considered this record suspicious. In her paper describing this species Wiley (1923) gives the following data: "Holotype: apterous male, collected near Rock Island, Texas, Aug. 2, 1922 (Grace O. Wiley); in author's collection." In 1922, before air travel was common, it is unlikely that she was in eastern Texas and Utah on the same day. Mrs. Wiley undoubtedly collected these specimens in Texas, perhaps at Cisco. There is a town of the same name in Grand County, Utah, near the Colorado River. The border between Emery and Grand counties in Utah is the Green River and it could be easy to misread the map and place Cisco in Emery County. The Colorado River (of Texas, not Utah) flows a few miles east of Rock Island, another confusing coincidence. Mrs. Wiley lists as paratypes specimens taken in June near Cisco, Texas (in Eastland County, about 250 miles north of Rock Island), but does not mention any from Utah collections. Utah should be removed from the United States distribution of this species. Although there are published records of *Rheumatobates* from Saskatchewan, Arizona, New Mexico, and much farther west in Mexico, as far as we can determine, the 100th meridian essentially marks the western boundary of distribution of *Rheumatobates* in the middle latitudes of the United States.

*Rheumatobates hungerfordi* is common in central and eastern Texas and along the east coast of Mexico, particularly in Veracruz, and ranges southward to Belize. It is less common in other southern parts of the United States states but ranges as far north as Missouri (Smith 1988). With his collections at Carlsbad, New Mexico (most likely the Pecos River), and El Paso, Texas, Drake extended the known distribution westward along the Rio Grande drainage (Drake and Harris 1937). Drake and Hottes (1951) list it from Arizona, but we have been unable to confirm that record. They also give localities in the eastern Mexican states of Puebla, San Luis Potosi, Tamaulipas, and Veracruz. In addition to many collections from Texas, we have the following records from Mexico and Mesoamerica.

BELIZE: Mountain Pine Ridge, Rio On, CL 644, 31 Dec. 1973, JTP.

MEXICO: *CHIAPAS: Montebello Lakes, CL 1083, 3 May 1964, JTP & MSP. *OAXACA: Valle Nacional, CL 506, 4 June 1971, JTP & MSP. VERACRUZ: Rio Blanco, La Tinaja, CL 504, 4 Jan. 1971, JTP & MSP; Rio Paso de Ovejos, CL 513, 6 Jan. 1971, JTP & MSP; N. of Nuatla, CL 518, 7 Jan. 1971, JTP & MSP; 17 mi. S. of Tuxpan, CL 521, 7 Jan. 1971, JTP & MSP; 5 mi. S. of V. Alatorre, CL 675, 8 Jan. 1974, JTP.

### *Rheumatobates imitator* (Uhler, 1894)

Spangler, Froeschner, and Polhemus (1985) listed Martinique without specific locality data, which is: MARTINIQUE: Rivière Salée S. ditch, 12 July 1967, P. W. Hummelinck.

### *Rheumatobates mexicanus*
### Drake & Hottes, 1951

This species was originally described from the state of Guerrero, Mexico, with additional localities recorded in the states of Aguascalientes, Mexico D. F., Oaxaca, Puebla, San Luis Potosi, Tamaulipas, and Veracruz. This species is widespread and common in Mexico, and also occurs farther south. We have the following records.

*HONDURAS: 17 mi. E. of Jicaro Galan, CL 1311, 9 Jan. 1970, JTP.

MEXICO: *COLIMA: Melaque, CL 1226, 20 Nov. 1968, JTP; Santiago, CL 1227, 25 Nov. 1968, JTP; Cuyutlan, CL 1228, 26 Nov. 1968, JTP. GUERRERO: Ixtapa, CL 1892, 27 Jan. 1985, JTP; large lagoon N. of Pie de la Cuesta, CL 1046, 26 Apr. 1964, JTP & MSP. *JALISCO: Puerto Vallarta, CL 731, 4 June 1975, JTP; Tenacatita, CL 738, 10 June 1975, JTP. *NAYARIT: Santa Cruz, CL 728, 8 June 1975, JTP; San Blas, CL 1208 & CL 1209, 3 June 1966, JTP; 7 mi. NE of San Blas, CL 1025, 21 Apr. 1964, JTP & MSP. *SINALOA: Escuinapa, CL 1023, 21 Apr. 1964, JTP & MSP.

### *Rheumatobates minimus* Drake, 1958

In addition to the type locality in Peru, we can add the following.

BRAZIL: Ponte Nova, 29 July 1967, R. L. Usinger; Nova Teutonia, Santa Catarina, May 1957, F. Plaumann.

### *Rheumatobates minutus minutus* Hungerford, 1936

Hussey (1955) reported this species as new to the Untied States based on collections from Lakeland and the Big Pine Key in Florida. Herring (1958) considered its presence there to be the result of hurricane transport, and questioned whether breeding populations were established in the United States. In the Polhemus collection we have specimens taken in the month of November by H. C. Chapman at Christmas and Orlando, Florida. D. A. Polhemus (personal communication) has recently seen in March and August an established breeding population near Everglades City, so this species can be considered a permanent resident of Florida. It is common in Mexico and Mesoamerica from which we have the following records.

*BELIZE: Beaver Dam Cr., CL 629, 27 Dec. 1973, JTP; 10 mi. W. of Stann Creek, CL 639, 27 Dec. 1973, JTP.

COSTA RICA: 10 mi. S. of Palmar Sur, CL 1281, 28 Dec. 1969, JTP; S. of San Isidro del General, CL 1302A, 6 Jan. 1970, JTP.

*GUATEMALA: Peten, 3 mi. S. of Tikal, CL 653, 2 Jan. 1973, JTP.

MEXICO: *CAMPECHE: Edzna, Pond, CL 613, 15 Dec. 1973, JTP. *QUINTANA ROO: Tulum, CL 621, 20 Dec. 1973, JTP. *VERACRUZ: 16 mi. S. of La Tinaja, CL 505, 4 Jan. 1971, JTP & MSP; S. of Gutierrez Zamora, CL 519, 7 Jan. 1971, JTP & MSP; Papantla, CL 520, 7 Jan. 1971, JTP & MSP; S. of Loma Bonita, CL 1333, 15 Jan. 1970, JTP; N. of Nuatla, CL 518, 7 Jan. 1971, JTP & MSP.

### *Rheumatobates minutus flavidus* Drake & Harris, 1942

The distribution of this subspecies abuts that of the nominal subspecies in Costa Rica, and we can find no isolating mechanisms. In the series from Nuatla, Veracruz, Mexico, and Tikal, Guatemala (see above), the males and winged specimens key to *minutus minutus* but the apterous females key to *minutus flavidus,* so we question the distinctness of these subspecies. There appears to be a gradation between the two forms in Mesoamerica. We have the following records.

COSTA RICA: San Vito de Java, CL 1284, 29 Dec. 1969, & CL 1286, 31 Dec. 1969, JTP.

*PANAMA: San Carlos, CL 1290, 1 Jan. 1970, JTP; Portobello, CL 1292, 1 Jan. 1970, JTP.

PERU: SAN MARTIN DEPT.: 8 km. ENE of Tarapota, 550 m, 9 Jan. 1974, R. T. Schuh (AMNH).

### *Rheumatobates petilus* Drake & Hottes, 1951

This species was originally described from the state of Guerrero, Mexico, and is additionally known from the state of Campeche on the opposite coast (Hungerford 1954). We have specimens from a tidal estuary emptying into the Gulf of Mexico.

MEXICO: *TABASCO: near Paraiso, Estuary, CL 607, 12 Dec. 1973, JTP.

### *Rheumatobates spinosus* Hungerford, 1954

This species was reported from Bolivia without specific locality data by Spangler, Froeschner, and Polhemus (1985). We have the following records.

BOLIVIA: Santa Cruz, 22 Oct. 1957, G. Pinckert (also in USNM: see Drake, 1958); Beni, Rio Itenez, opposite Costa Marques (Brazil), 4–6 Sept. 1964, Bousemann & Lussenhop (AMNH).

### *Rheumatobates vegatus* Drake & Harris, 1942

*Rheumatobates vegatus* was described from Cuba and has been reported additionally from Florida and Puerto Rico. It is common around mangroves in southern Florida. Herring (1949) listed it from three Florida localities and described it as a new species, *R. crinitus,* which is now synonymized with *R. vegatus.* JTP collected it at Coral Gables (Matheson Hammock Pk., CL 410, 4 Feb. 1968), where it was swarming beneath the mangroves. In March and August, 1988, D. A. Polhemus found it in large numbers on salt water around mangroves near Everglades City, Florida.

We found this species to be common in mangrove habitats in Belize. JTP took a series from a limestone rimmed lagoon along the Caribbean side of the Yucatan Peninsula where freshwater from huge springs mingled with the sea water.

*BELIZE: Cay Caulker, CL 624, 24 Dec. 1973, & CL 628, 28 Dec. 1973, JTP. STANN CREEK DISTR.: Twin Cays, West Bay, red mangrove tidal flats, 11 Nov. 1987, P. J. Spangler, R. A. Faitoute (USNM).

MEXICO: QUINTANA ROO: Xel-ho, CL 619, 20 Dec. 1973, JTP.

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# TWO NEW SPECIES OF *COCCIPOLIPUS* (ACARI: PODAPOLIPIDAE) PARASITES OF *CHILOCORUS* SPP. (COCCINELLIDAE) FROM VERA CRUZ AND MORELOS, MEXICO AND FLORIDA AND WISCONSIN, U.S.A.

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*Abstract.*—***Coccipolipus oconnori*** n. sp. (Acari:Podapolipidae) is parasitic on *Chilocorus stigma* (Coccinellidae) at several localities in Florida and near Sauk City, Wisconsin, U.S.A. and ***Coccipolipus cactii*** n. sp. is parasitic on *Chilocorus cacti* from Vera Cruz and Morelos, Mexico. The new species is closest to the African *Coccipolipus chilocori* Husband 1981. New distributional records of *C. macfarlanei* include Wenatchee, Washington and Castelar, Argentina.

*Key Words:* Acari, Podapolipidae, *Coccipolipus, Chilororus,* parasite, new species, mites

Mites of the genus *Coccipolipus* are subelytral parasites of coccinellid beetles, with the greatest diversity of known species occurring in Africa (Husband 1972, 1981, 1984a, b). To date, only one species of *Coccipolipus* has been collected from the beetle genus *Chilocorus, C. chilocori* Husband, 1981. During studies of the phoretic associations between the mite genus *Hemisarcoptes* (Hemisarcoptidae) and *Chilocorus,* B. M. OConnor and M. A. Houck of the University of Michigan examined over 5000 museum specimens of *Chilocorus.* Collections representing two new species of *Coccipolipus* from North American *Chilocorus* species were recovered during the study. These species, each restricted to a single species of *Chilocorus,* are described below. All beetles from which *Coccipolipus* specimens were recovered are housed in the U.S. National Museum of Natural History collections unless otherwise noted. Insects are vouchered with labels reading "Mites removed, B. M. OConnor" and a voucher number corresponding to the number on the mite slides.

Measurements were made using a Wild phase contrast microscope with a drawing tube calibrated from a stage micrometer. Terminology is based on Lindquist (1986). All measurements are in micrometers (mm).

## *Coccipolipus oconnori*, New Species

Female (Figs. 1, 2).—Gnathosoma longer than wide; length 57, width 41. Cheliceral stylets slender, smooth, length 21. Pharynx length 29, width 23. Gnathosoma usually retracted into sclerotized chamber. Stigmata on slender stalks dorsolateral to gnathosoma. Palps prominent. Tectum covers gnathosoma, length 60, width 45. Idiosoma—smooth, lightly sclerotized; length 445–486, width 251–278. Fully developed females with anterolateral lobes wider than posterior idiosoma. Lightly sclerotized posteroventral internal triangular structure, length 105–148, width 85–125. Legs—two pairs; anterior pair without sucker-like pad, with well developed hooked spine and terminal spine, anterior femoral setae, 5. Leg II with 2 terminal spines, an-

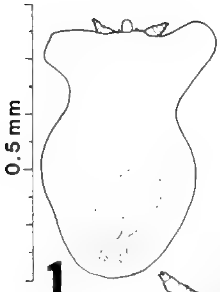

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Fig. 1. *Coccipolipus oconnori* n. sp., female, dorsal aspect.

Fig. 2. *Coccipolipus oconnori* n. sp., female, partial ventral aspect.

Fig. 4. *Coccipolipus oconnori* n. sp., male, ventral aspect.

terior spine nearly as thick but about ¾ length of posterior spine.

Male (Figs. 3, 4).—Gnathosoma length 22, width 25; dorsal setae microsetae, ventral setae, length 2. Palps 2-segmented, distal segment truncate, basal segment with a short seta. Cheliceral stylets length 8, about ⅓ gnathosomal width. Idiosoma—length 120, width 100. Dorsum-prodorsal plate narrows anteriorly, all setae microsetae. Plates C and D fused, all setae microsetae; triangular aedeagus extends anteriorly beyond posterior margin of prodorsal plate. Venter—slightly sclerotized apodemes 1 and 2 meet medially at sternal apodeme. Coxae III fused, separate from coxae I,II. Legs—leg setation as in Table 1. Leg I with a terminal stout claw and an anterolateral stout spine with 2 adjacent thick setae as long as the spine. Solenidion $\omega$ reduced, scarcely longer than width of setal socket. Solenidion $\phi$ not apparent. Tibia I d seta length 19. Femur II seta present. Tarsi II,III with 2 spine-like setae, ventral spine with an adjacent seta shorter than spine. Ambulacra II, III 15, 12; with minute symmetrically paired claws, length 1. One spine on tibia I, 3 spines each on tibiae II,III, spine lengths 4–5. Tarsus and tibia III longest setal length 6, genu III seta spine-like.

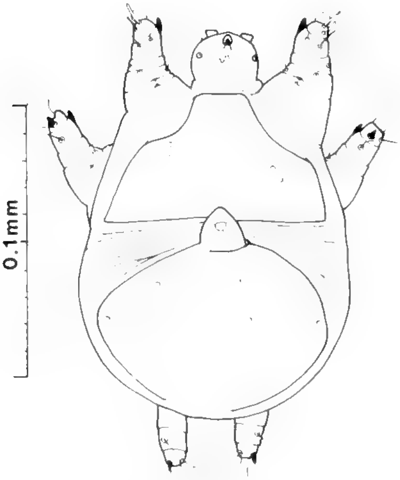

Fig. 3. *Coccipolipus oconnori* n. sp., male, dorsal aspect.

Larval female (Figs. 5, 6).—Gnathosoma length 50, width 50; dorsal setal length 8, less than ⅕ gnathosomal width, ventral setae length 4. Palps 2-segmented, small seta on each segment. Stylets smooth, slender, length 30. Idiosoma—length 186, width 141. Dorsum-prodorsal plate narrowed anteriorly; $v_1$ 4, $sc_2$ 99. Plates C and D fused. All setae microsetae. Plate EF wider than long, setae f length 10. Plate H somewhat trian-

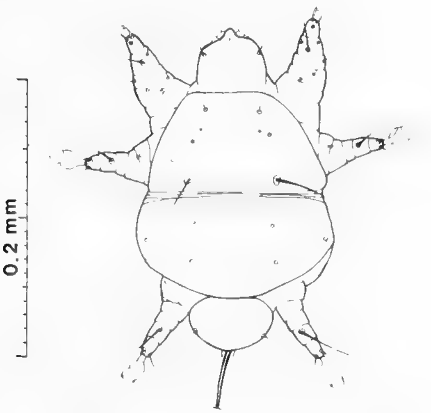

Fig. 5. *Coccipolipus oconnori* n. sp., larval female, dorsal aspect.

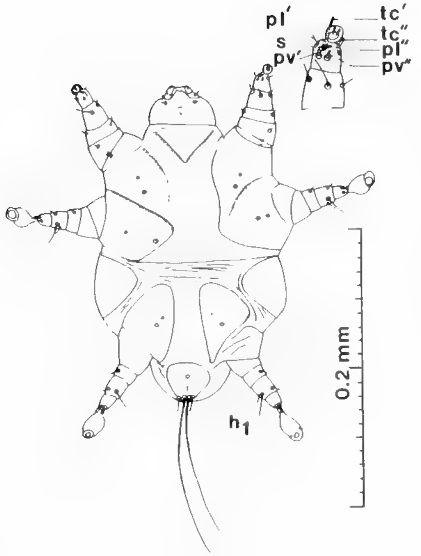

Fig. 6. *Coccipolipus oconnori* n. sp., larval female, ventral aspect. Notation (after Lindquist 1986); pl, primilateral; pv, primiventral; s, subunguinal; tc, tectal; h, setae associated with plate H (6th opisthosomal segment).

gular; setae $h_1$ length 11, $h_2$ length 168. Venter-apodemes poorly sclerotized; apodemes 1 and 2 meet medially at anterior sternal apodeme. Coxae III separate from each other and from coxae I,II. Legs—leg setation as in Table 1. Leg I with 2 parallel, terminal claws, solenidion $\omega$ length 2. Thick tarsus I pv′ · pv″ setae at base of spine-like s seta. Seta tc′ slightly less than twice length of seta tc″. Tarsi II,III each with setae tc′ and u subterminal, spine-like. Solenidion $\phi$ no longer than width of setal socket. Ambulacra II,III 28, 25, with minute symmetrically paired claws.

Type data.—Holotype male: Enterprise, Volusia County, Florida, U.S.A., from male *Chilocorus stigma* (Say) (Coccinellidae) collected May 25 (year unknown) by Hubbard and Schwarz. Deposited in the United States National Museum (U.S.N.M.) collection, Washington, D.C. (BMOC 86-0703-18-1). Paratypes (8 males, 20 larval females, 23 females)—same data as holotype. One female (BMOC 86-0703-31-43) and one larval female (BMOC 86-0703-31-42) Hillsboro Co., Florida, collected 7–12 April 1930 by J. C. Bowver on *C. stigma.* One larval female (BMOC 86-0703-26-440) Brevard Co., Florida on 19 April 1930 by R.A. Schlernitsauer on *C. stigma.* Two females (BMOC 86-0703-27-45, -46) Osceola Co., Florida between 7–12 April 1930 by M. M. Smith on *C. stigma.* Two females (BMOC 86-0703-22-47, -48) Orange Co., Florida on 21 July 1929 by W. A. Miers on *C. stigma.* One female (BMOC 86-0703-19-49) Sump-

Table 1. Total setae on legs of *Coccipolipus* spp. parasitic on *Chilocorus* spp. Solenidia are included.

| | Leg I | | | | Leg II | | | | Leg III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F | G | Ti | Ta | F | G | Ti | Ta | F | G | Ti | Ta |
| *C. oconnori* n. sp. | 3 | 3 | 6 | 8 | 1 | 1 | 4 | 4 | 0 | 1 | 4 | 4 |
| *C. cacti* n. sp. | 3 | 3 | 6 | 8 | 1 | 1 | 4 | 4 | 0 | 1 | 4 | 4 |
| *C. chilocori* H. | 2 | 3 | 6 | 8 | 0 | 1 | 4 | 4 | 0 | 1 | 4 | 4 |

ter Co., Florida, 10–14 Feb. 1930 by B. L. Smith on *C. stigma.* One female (BMOC 86-0703-16-50) Flagler Co., Florida on 21 Dec. 1929 by E. B. Webb on *C. stigma.* Two males (BMOC 87-1023-3-1,-2), 3 larval females (BMOC 87-1023-3-3, -4, -5)) and 6 females (BMOC 87-1023-3-6, -7, -8, -9, -10, -11) Sauk Co., Wisc., on 1 Sept. 1960 by G. Lockwood on *C. stigma.* Three males (BMOC 86-0703-18-2, -3 and BMOC 87-1023-3-1), 4 larval females (BMOC 86-0703-18-9, -10, -11 and BMOC 87-1023-3-3) and 4 females (BMOC 86-0703-18-25, -26, -27 and BMOC 87-1023-3-6) are in the collections of Adrian College, Adrian, Michigan, U.S.A. Three males (BMOC 86-0703-18-4, -5 and BMOC 87-1023-3-2), 3 larval females (BMOC 86-0703-18-12, -13 and BMOC 87-1023-3-4) and 3 females (BMOC 86-0703-18-28, -29 and BMOC 87-1023-3-7) are deposited in the Museum of Zoology, the University of Michigan, Ann Arbor, Michigan. The remaining paratypes are deposited in the U.S.N.M., Washington, D.C.

Etymology.—The species is named for Dr. Barry M. OConnor of the University of Michigan in tribute to his basic studies in the field of acarology.

## DIAGNOSIS

Of the 13 species of *Coccipolipus,* only 4 have femoral II setae and 3 of the 4, including *C. oconnori,* have plates C and D completely fused in the larval female stage. *C. oconnori* and the species described below have $h_1$ setae (length 11) which are longer than the distance between setae $h_1$. The remaining species, *C. coormani,* has setae $h_1$ (length 2) which are shorter than the distance between setae $h_1$. *C. oconnori* has gnathosomal setae which are 20% shorter than the species described below. Setae $sc_2$, f, femoral I l′ and tibial I l′ are shorter in *C. oconnori* than in the new species described below.

Six of the 13 species of *Coccipolipus* have males with three spine-like setae on tibia III but only 3 species, including *C. oconnori* have spine-like setae on genua III. *C. oconnori* and *C. cooremani* share the 2 characters above while *C. bifasciatus* has 2 spine-like setae on tibia III in combination with spine-like setae on genu III. The tibial III shortest seta in *C. oconnori* is shorter (length 6) than the basal width of tibia III (12) in contrast to the same tibial seta (length 20) in *C. cooremani* in which basal width of tibia III is 14.

Adult females of *C. oconnori* and the species described below have femoral I setae (length 5) which do not extend beyond the distal margin of genu I. Five *Coccipolipus* spp. have femoral setae (lengths 13–18) which extend beyond the distal margin of tibiae I. The remaining 6 species lack femoral I setae. Typically, anterior lobes of female *C. oconnori* do not extend beyond the anterior margin of the gnathosoma and the width of the width of the anterior idiosoma is greater than the width of the posterior idiosoma. The two characters contrast with the condition in adult females of the species described below.

## *Coccipolipus cacti,* NEW SPECIES

Female (Figs. 7, 8).—Gnathosoma length 60, width 48; cheliceral stylets smooth, slender, 23. Muscular pharynx length 35, width 26. Gnathosoma often retracted into a sclerotized chamber. Stigmata on slender stalks dorsolateral to gnathosoma. Palps prominent. Tectum covers gnathosoma, length 60, width 50. Idiosoma smooth, lightly sclerotized; length 260–560, width 200–375. Fully developed females with anterolateral lobes less than or equal to widest part of posterior idiosoma. Lightly sclerotized, triangular, internal, posteroventral, structure, length 90–165, width 76–125. Legs—two pairs; anterior pair without sucker-like pad, with well developed hook-like spine and terminal spine, anterior femoral seta 5. Legs II with 2 terminal spines, anterior spine ½ width and length of posterior spine. Apodemes 1 and 2 thin and weakly sclerotized but conspicuous.

Male (Figs. 9, 10).—Gnathosoma length

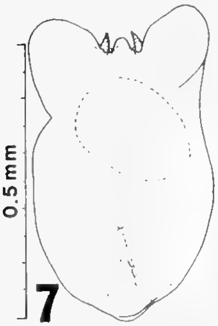

Fig. 7. *Coccipolipus cacti* n. sp., female dorsal aspect.

Fig. 8. *Coccipolipus cacti* n. sp., female, partial ventral aspect.

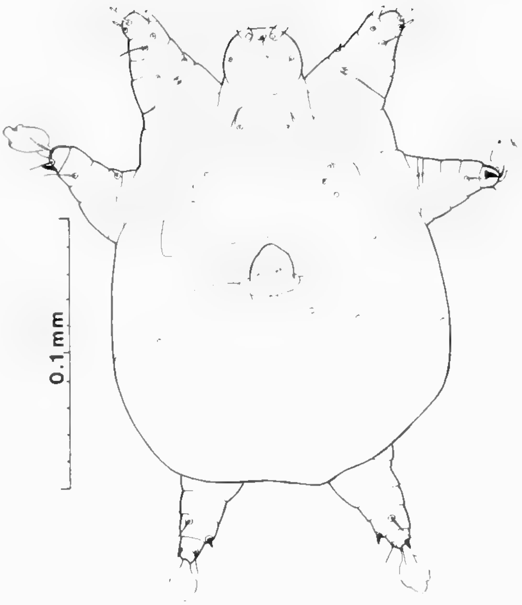

Fig. 9. *Coccipolipus cacti* n. sp., male, dorsal aspect.

26, width 29; dorsal and ventral setae 2. Conspicuous muscular pharynx. Palps 2-segmented, distal segment truncate, proximal segment with a short lateral seta. Cheliceral stylets 8, about ⅓ width of gnathosoma. Idiosoma—length 140, width 124. Dorsum-prodorsal plate narrow anteriorly, all setae microsetae. Triangular aedeagus extends beyond posterior margin of prodorsal plate (not evident in Fig. 9 because the specimen was flattened to observe other structures). Venter–slightly sclerotized apodemes 1 and 2 meet medially at the sternal apodeme. Coxae III fused, separate from coxae I,II, coxal setal bases evident but without setae. Legs—leg setation as in Table 1. Leg I with terminal stout claw and anteroventral subterminal spine. Solenidion $\phi$ not apparent. Tibial setae l′ are small thorns no longer than diameter of setal sockets. Tibia I d seta 22, femur II seta present. Tarsi II,III with 2 spine-like setae; ambulacra II,III 20,18, with minute, symmetrically paired claws. One spine on tibia I, two spines on tibiae II,III, spine lengths 5–6. Tibia III seta 14, tarsus III longest seta 10, about equal to tarsus III basal width.

Larval female (Figs. 11, 12).—Gnathosoma length 44, width 48, dorsal setae 10, ventral setae 8. Pharynx bulb-shaped. Palps 2-segmented, distal segment setal length 3, proximal seta 1. Stylets smooth, slender, length 40. Idiosoma—length 180, width 139. Dorsum-prodorsal plate quadrate, narrowed anteriorly; $v_1$ 5, $sc_2$ 127. Plates C and D fused, all setae microsetae. Plate EF wider than long, setae f 12. Plate H somewhat

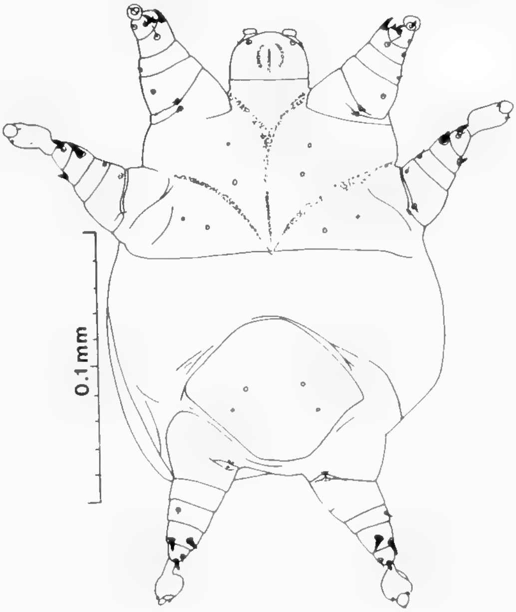

Fig. 10. *Coccipolipus cacti* n. sp., male, ventral aspect.

Fig. 11. *Coccipolipus cacti* n. sp., larval female, dorsal aspect.

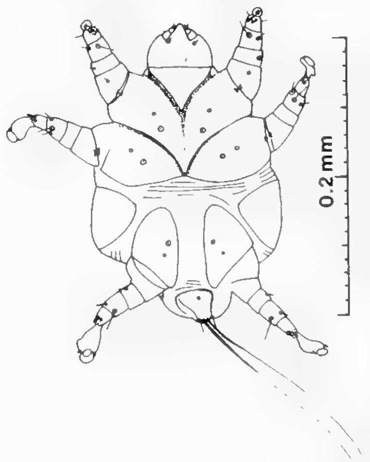

Fig. 12. *Coccipolipus cacti* n. sp., larval female, ventral aspect.

triangular; setae $h_1$ 11, setae $h_2$ 183. Venter—apodemes weakly sclerotized, 1 and 2 meet medially at anterior sternal apodeme. Coxae III separated from each other and from coxae I,II, all coxal setae microsetae. Legs—leg setation as in Table 1. Leg I with 2 parallel, terminal claws, solenidion $\omega$ no longer than diameter of socket. Setae $tc'$ slightly more than 2 times length of setae $tc''$. Solenidion $\phi$ absent or vestigial. Ambulacra of legs II,III 22 and 30 respectively, with minute paired claws.

Type data.—Holotype male: Cordoba, Vera Cruz, Mexico, on *Chilocorus cacti* (Linnaeus) (Coccinellidae) collected April 21, 1908 by F. K. Knab (BMOC 86-0707-63-1). Deposited in the United States National Museum, Washington, D.C. Paratypes (2 males, 19 larval females, 9 adult females)—same data as holotype. One female (BMOC 86-0918-7-32), 3 miles S. Alpuyeka, Morelos, Mexico, 3400 ft. elev., collected 8 April 1959 by H. E. Evans on *C. cacti*; host beetle in the Cornell University Insect Collection. One male (BMOC 86-0707-63-2), 3 larval females (BMOC 86-0707-63-4, -5, -6) and 2 females (BMOC 86-0707-63-23, -24) are deposited in the collection at Adrian College, Adrian, Michigan. One male (BMOC 86-0707-63-3), 3 larval females (BMOC 86-0707-63-7, -8, -9) and 2 females (BMOC 86-0707-63-25, -26) are deposited in the collections of the Museum of Zoology, the University of Michigan, Ann Arbor, Michigan. One female (BMOC 86-0918-7-32) is deposited in the Cornell University Insect Collection, Ithaca, N.Y. The balance of paratypes are deposited in the U. S. National Museum of Natural History.

Etymology.—The species is named for the host species, *Chilocorus cacti*.

## DIAGNOSIS

*Coccipolipus cacti* is similar to *C. oconnori*. Larval female *C. cacti* have longer cheliceral stylets, gnathosomal setae, and $sc_2$, f, $h_2$, femoral and tibial I $l'$ setae. Male *C. cacti* have minute thorn-like tibial setae $l'$ while male *C. oconnori* have typical slender tibial $l'$ setae. Male *C. cacti* have typical genu III setae while male *C. oconnori* have spine-like genu III seta. Adult female *C. cacti* have anterolateral lobes which extend beyond the anterior margin of the gnathosoma and are less than or equal to the greatest width of the posterior idiosoma. Leg II spines in *C. cacti,* although not equal in length are equal in width. In *C. occonori,* the posterior tarsal spine is nearly twice the thickness of the anterior tarsal spine.

## Discussion

Some species of *Coccipolipus* are wide ranging in both host association within Coccinellidae and in geographic distribution, e.g. *C. macfarlanei* on 3 genera of coccinellid beetles on 3 continents. In contrast, *C. chilocori, C. oconnori* and *C. cacti* are restricted to the genus *Chilocorus* and each to a portion of a continent. *C. chilocori* occurs on 5 species of *Chilocorus* in Central Africa, *C. cacti* occurs on one species in Mexico and *C. oconnori* occurs one one species in the Eastern United States. This discussion is limited to the 3 species of *Coccipolipus* associated with *Chilocorus* spp.

African *C. chilocori* are larger, have longer setae in general and longer leg setae specifically in females, males and larval females than their counterparts *C. cacti* and *C. oconnori* in North America.The idiosomal length of larval female *C. chilocori* is about 1.2 times the length of the American species but gnathosomal setae are 2 to 4 times longer than the American species. Comparisons of the longest tibial and tarsal III setae in males and femoral setae in females give ratios of 2 to 6 times longer than in the American species.

Although males of all 3 species are similar in that all idiosomal are microsetae, the aedeagus of *C. chilocori* extends farther forward and is nearly equal to the width of the gnathosoma. The aedeaguses of *C. oconnori* and *C. cacti* are at most ¾ the width of the gnathosoma. Femoral I, II, III setal patterns in male and larval female *C. oconnori* and *C. cacti* are 3-1-0 whereas the pattern in the African species is 2-0-0. Patterns on genua, tibiae and tarsi are similar. Empodia are conspicuously longer and more slender in male and larval female *C. chilocori* than in American species.

Since the genus *Chilocorus* is found in both hemispheres and has a wide distribution pattern, it is likely that additional *Coccipolipus* will be discovered. At this point, it may be stated that there are differences in numbers of setae, setal lengths and size of structures between *Coccipolipus* from African *Chilocorus* and *Coccipolipus* from North American *Chilocorus*. The differences are consistant in the species studied.

### Additional distribution records of *Coccipolipus* spp.

In addition to records cited above and in Husband(1984b), *Coccipolipus macfarlanei* Husband 1972 is now known from *Coccinella transversoguttata* (Fald.), 6 mi. N. of Wenatchee, Washington, U.S.A. (Devin Carroll, personal communication, 1983) and from *Eriopis connexa* (Germ.) in Castelar, Argentina (Alida Bolart, personal communication, 1983).

## Acknowledgments

Collections of mites from *Chilocorus* beetles was funded by a grant from the National Science Foundation to B. M. OConnor and M. A. Houck (BSR 83-07711). I thank B. M. OConnor for his review of the manuscript.

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# A NEW SPECIES OF *ALEUROTULUS* (HOMOPTERA: ALEYRODIDAE)

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*Abstract.*—The pupal cases and third instar of ***Aleurotulus anthuricola***, new species, are described. This whitefly is apparently host-specific to *Anthurium* spp. and is endemic to Colombia and several islands in the Lesser Antilles. It was detected in Hawaii in 1978.

*Key Words:* *Aleurotulus, anthuricola,* Aleyrodidae, whitefly, *Anthurium* spp., Hawaii

*Aleurotulus anthuricola,* new species, is apparently host-specific on *Anthurium* spp. (Araceae) and endemic to Colombia and several islands in the Lesser Antilles. In 1978 it was discovered in Hawaii on the inner surface of leaf sheaths of anthurium plants. Injury was not observed on infested plants and therefore, *anthuricola* was of minor concern to the anthurium flower industry in Hawaii. In recent years however, infestations were found on the flower spathes and although the damage is negligible, *anthuricola* has become a major pest because of problems with agricultural quarantine regulations. Infested flowers, unless treated, cannot be exported from Hawaii to the continental United States and other uninfested areas of the world. A description is presented here to provide a scientific name for biological and control studies now in progress in Hawaii.

Measurements are based on 10 specimens. The values are given first for the holotype followed by those for the paratypes in parentheses. The terms pupae and pupal cases are used interchangeably in this paper.

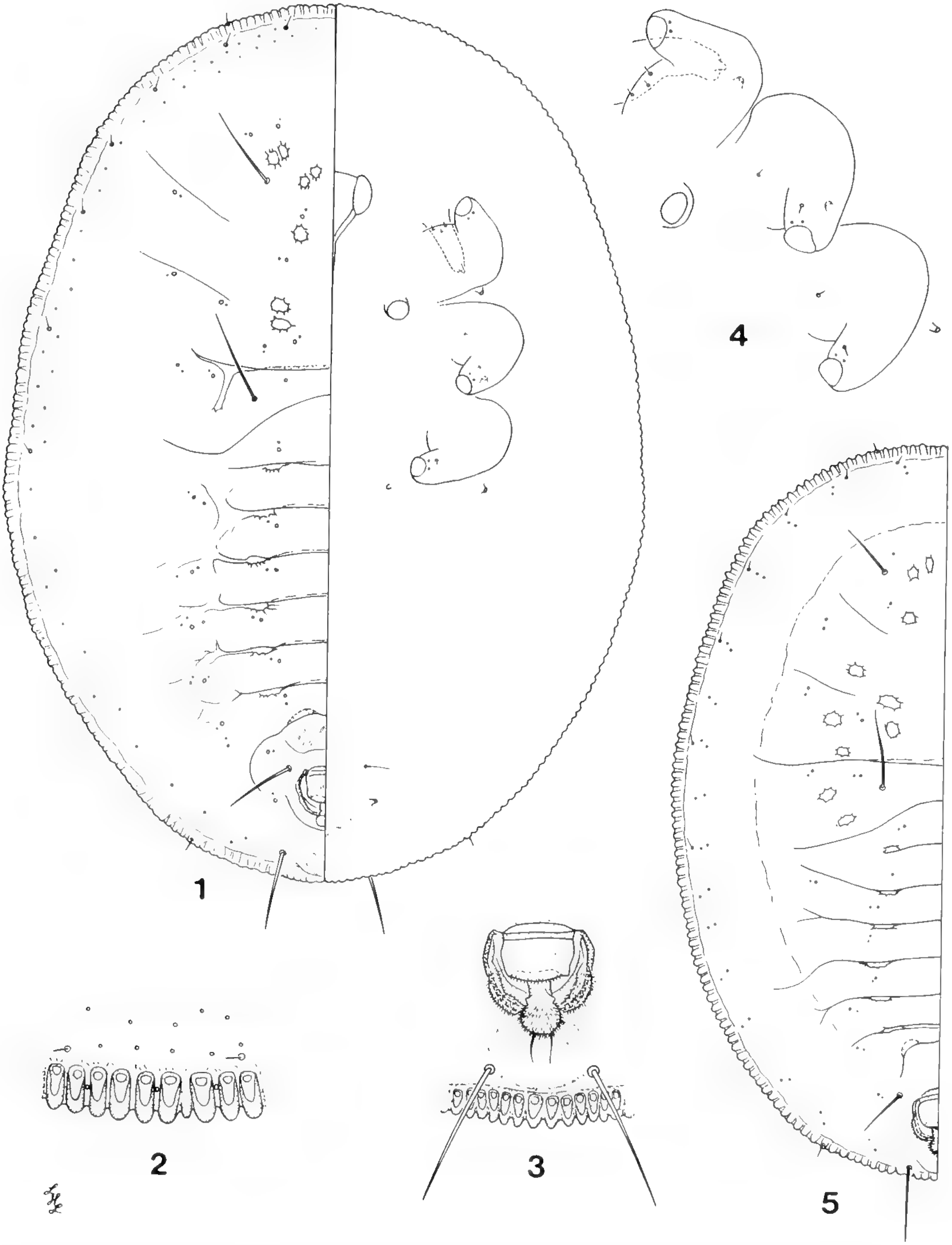
## ***Aleurotulus anthuricola*** **Nakahara, NEW SPECIES**

Figs. 1–7

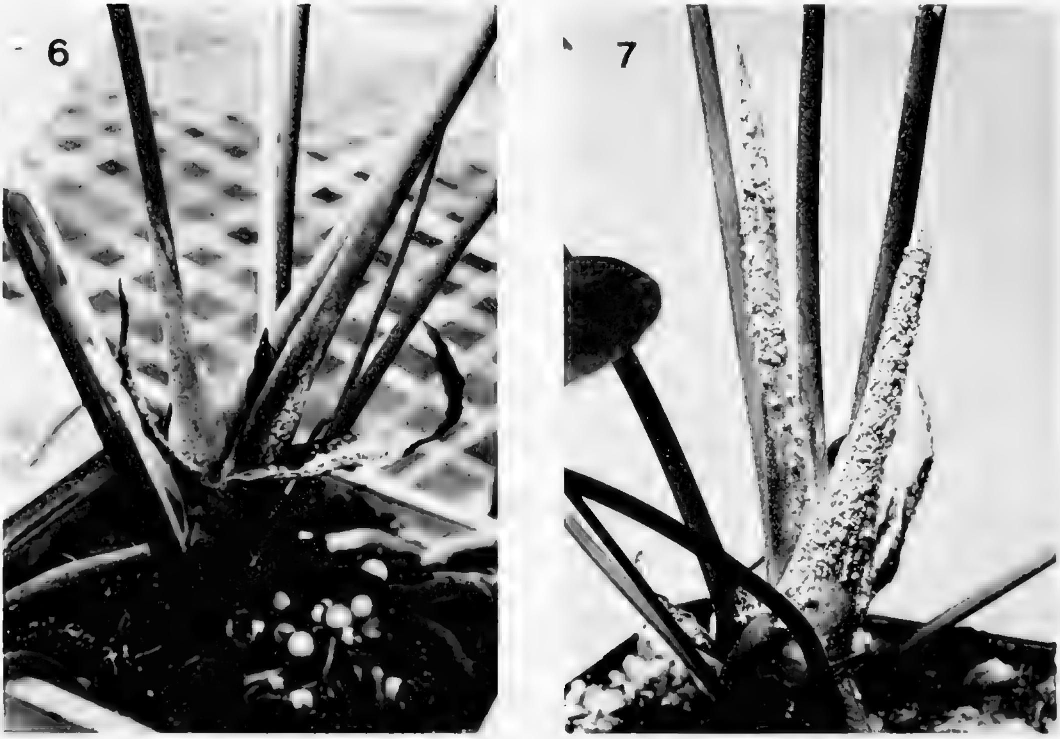
Pupae and third instar larvae grayish black; margins pale; with fringe of white, filamentous wax. Often clustered in a mass of white, filamentous wax on inner surface of leaf sheaths and flower spathes and on leaf petioles. Severe infestions also on outer surface of sheaths and on flower spathes (Figs. 6–7).

*Pupa* (Fig. 1): Pupal cases broadly oval. Measurements of slide mounted specimens: Length 880 (623–955) μm, width 636 (438–677) μm.

*Margin and submargin* (Fig. 2): Margin dentate, 13 (13–16) teeth per 100 μm on lateral margin. Teeth of two types: those with elongate, triangular areas at bases; smaller ones without triangular areas. Tracheal pore area undifferentiated. Anterior marginal setae 15 (12–20) μm long, 14 (6–18) teeth from midline; posterior marginal setae 24 (17–30) μm long, 34 (34–45) teeth between setae. Submargin not differentiated



Figs. 1–5. Fig. 1. Pupa habitus (148×). Fig. 2. Marginal and submarginal areas (390×). Fig. 3. Vasiform orifice and dorsal caudal area of pupal case (308×). Fig. 4. Thoracic legs and antennae (230×). Fig. 5. Third instar larva habitus (202×).



Figs. 6–7. Fig. 6. Typical infestation in leaf sheath of anthurium. Fig. 7. Severe infestation on the petioles of anthurium.

from dorsal disc by fold or furrow; with short, transverse ridges; each ridge with elongate triangular area extending into marginal tooth; proximal part of area with an oval, pale spot. Micropore between ridges, in irregular spaced row around case. Submarginal setae 12–20 μm long; 6 pairs on cephalothorax, 1 pair on anterior abdominal segment. Small disc pores about 1 μm in diameter mesad of ridges and submarginal setae. Oval, transverse tubercle between caudal setae.

*Dorsal disc:* Derm smooth. Eyespots absent. Longitudinal molting suture extending to anterior margin; transverse molting suture extending caudolaterally and anteriorly into subdorsum, lateral ends not attaining level of its midpoint; sutures smooth; other cephalothoracic segmental division obscure. Submedial furrow on metathorax extending obliquely from suture. Cephalic setae 74 (49–84) μm long; metathoracic setae 62–99 μm long, in posterior ½ of segment; eighth abdominal setae 64 (44–67) μm long, laterad of anterior margin of vasiform orifice. Caudal setae on distal part of submargin just mesad of submarginal ridges, 77 (49–77) μm long, extending beyond posterior margin, separated by 1.2–1.6 times width of vasiform orifice; transverse tubercle between setae. Shallow, oval, submedial depressions on head, prothorax, mesothorax and 1 pair each on abdominal segments II–VIII. Medial area of abdomen slightly elevated; rachis slightly developed; medial part of segment VII about ½–¾ times as long as VI; segment VIII with medial tuberculate area between small pockets. Vasiform orifice (Fig. 3) subquadrate, 44 (35–42) μm long, 47 (44–47) μm wide, 1.5–2.5 times its length from posterior margin; rim thin, often covered by spinulose membranous inner wall that may extrude over rim; bottom of orifice open in anterior ⅔. Operculum irregularly transverse, caudal part membranous and spinulose, caudal margin rather straight or irregular; 24 (20–24) μm long, 37 (32–40) μm wide, occupying ½–⅗ length of vasiform orifice. Lingula spinulose; apical knob oval, with 2 setae, exposed, included or protruding posteriorly beyond orifice. Disc pores about 2 μm in diameter and smaller associated porettes distributed as follows: head with 1 submedial, 3 subdorsal pairs; prothorax with 1 submedial, 2 subdorsal pairs; mesothorax with 1 submedial, 2 subdorsal pairs; and metathorax with 1 submedial, 2 subdorsal pairs; abdominal segment I with 1 submedial pair, II with 0–1 submedial pair, III with 1 submedial and 1–2 subdorsal pairs, segments IV–VIII each with 1 submedial and 1 subdorsal pair.

*Venter.* Derm membranous, without distinct sculpture. Thoracic tracheal fold obscure, abdominal tracheal fold with spinules. Antenna (Fig. 4) not reaching anterior thoracic spiracle, apex with a small, conical point. Legs each with 2 distal setal bases and 4 basal setae, mesothoracic and metathoracic legs each with 1 distal seta. Eighth abdominal setae 22 (22–35) μm long, anterior of posterior abdominal spiracle.

*Third instar larva* (Fig. 5): Similar in shape and morphological characters as pupal cases. Length 537–562 μm, width 394–418 μm.

*Margin and submargin:* Margin broadly crenulate, 12–16 crenulae per 100 μm on lateral margin. Anterior marginal setae 10–12 μm long, separated by 12–17 crenulae; posterior marginal setae 12–24 long, separated by 19–28 crenulae. Submargin similar to pupal cases. Submarginal setae 7–10 μm long, 6 pairs on cephalothorax, 1 pair on anterior abdominal segment. Row of small disc pores mesad of setae.

*Dorsal disc:* Cephalic setae 24–53 μm long, metathoracic setae 49–67 μm long, eighth abdominal setae 37–42 μm long; caudal setae 54–67 μm long. Vasiform orifice 27–32 μm long, 35–37 μm wide, anterior of posterior margin by about its length. Operculum 17–20 μm long, 27–35 μm wide. Disc pores and associated porettes distributed as follows: cephalic segment with 1 submedial pair; prothorax with 0–1 subdorsal pair; mesothorax and metathorax each with 2 subdorsal pairs; abdominal segment I with 1 submedial pair; segments III–V with 0–1 submedial pairs; segments III and VI–VIII each with 1 subdorsal pair; occasionally present on segment IV.

*Type material:* Holotype pupal case, 11 pupal cases and 2 third instar larvae paratypes on slide labeled: Colombia, *Anthurium* sp., 31-VII-78, F. D. Matthews at Miami (78-7710). Other Paratypes: 6 pupal cases with same data as holotype slide. COLOMBIA: 7 pupal cases, *Anthurium* sp., 22-II-72, J. C. Buff, at Miami (72-5009); 5 pupal cases, *Anthurium* sp., 13-VII-73, E. B. Lee, at Miami (73-13786); 9 pupal cases, *Anthurium* sp., 20-III-79, G. Stone, at Miami (79-2655); 5 pupal cases, 5 third instar larvae, Anthurium, 13-XII-76, Froster, at Miami (77-967); 10 pupal cases (2 slides), *Anthurium* sp., 28-III-84, J. Russo, at Miami (84-3835); Bitaco, 3 pupal cases, *Anthurium* sp., 23-VII-58, F. T. Kenworthy (58-13126); Sasaima, 6 pupal cases, 10-VIII-72, F. Mosquiera Paris (72-18229). BARBADOS: 12 pupal cases, *Anthurium* sp., 8-II-80, L. Schroeder, at JFKIA (JFKIA 32840). DOMINICA: 7 pupal cases, *Anthurium* sp., 19-VI-81, E. B. Lee, at Miami (Miami 28783). GUADELOUPE: Duclos, 4 pupal cases, *Anthurium palmarum,* 20-III-87, J. Etienne (GR627). HAWAII: Aiea (Oahu), 23 third instar larvae (2 slides), *Anthurium* sp., 29-VIII-78, M. Rabago (78-8071); 6 pupal cases, 2 third instar larvae, 5-IX-78, L. Nakahara. MARTINIQUE: 11 pupal cases (2 slides), Anthurium, 8-III-71, J. C. Buff, at Miami (71-15065); 8 pupal cases (2 slides), *Anthurium andreanum,* 13-VII-78, R. Silvestre de Sacy; Morne-Rouge, 6 pupal cases, *Anthurium andreanum,* 16-V-81, L. Paley; St. Joseph, 26 pupal cases (5 slides), *Anthurium andreanum,* 16-VI-81, L. Paley;

TRINIDAD: 9 pupal cases, *Anthurium* sp., 10-IV-78, E. B. Lee, at Miami (Miami 17802). Holotype and paratypes in the aleyrodid collection of the U.S. National Museum of Natural History located at Beltsville, Maryland. Depositories of other paratypes: British Museum (Natural History), London; California Dept. of Food and Agriculture, Sacramento; Florida State Collection of Arthropods, Gainesville; and Hawaii Dept. of Agriculture, Honolulu.

*Etymology:* The specific epithet is a combination of the host plant, *Anthurium,* and latin "cola" which means inhabitant. This species is known only from *Anthurium.*

*Comments:* Of the four species currently assigned to the genus *Aleurotulus,* only the type-species, *nephrolepidis* (Quaintance 1900), which infests ferns in greenhouses in several countries, is well documented. The other three species (*arundinacea* Singh 1931, *maculata* Singh 1931, and *mundururu* Bondar 1923) are known only from their original collections. *Aleurotulus anthuricola* has well developed cephalic, metathoracic and eighth abdominal setae, and grayish black pupal cases; the corresponding setae of *nephrolepidis* are short and indistinct and the pupal cases are pale.

## ACKNOWLEDGMENTS

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# *SLIFERIA*, A NEW OVOVIVIPAROUS COCKROACH GENUS (BLATTELLIDAE) AND THE EVOLUTION OF OVOVIVIPARITY IN BLATTARIA (DICTYOPTERA)

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*Abstract.*—***Sliferia***, a new ovoviviparous blattellid cockroach genus from the Seychelle Islands is described. It includes *Sliferia lineaticollis* (Bolívar) n. comb., and *Sliferia* sp. False ovoviviparity occurs in 1 genus of Pseudophyllodromiinae, 1 genus of Blattellinae (Blattellidae), and practically all subfamilies and genera of Blaberidae. True ovoviviparity is found in 2 blaberid genera of Panesthiinae (Geoscapheini). False viviparity is known only in 1 species of Blaberidae (Diplopterinae). The evolution of ovoviviparity in the Blattaria is discussed.

*Key Words:* *Sliferia* n. gen., Blattellidae : Pseudophyllodromiinae, ovoviviparity, cockroaches

While studying some of Bolívar's types of cockroaches from the Seychelles, I found that *Blattella lineaticollis* Bolívar is ovoviviparous and belongs in a new genus which I describe here. The specimens were borrowed from the British Museum (Natural History) (BMNH).

### *Sliferia* Roth, New Genus

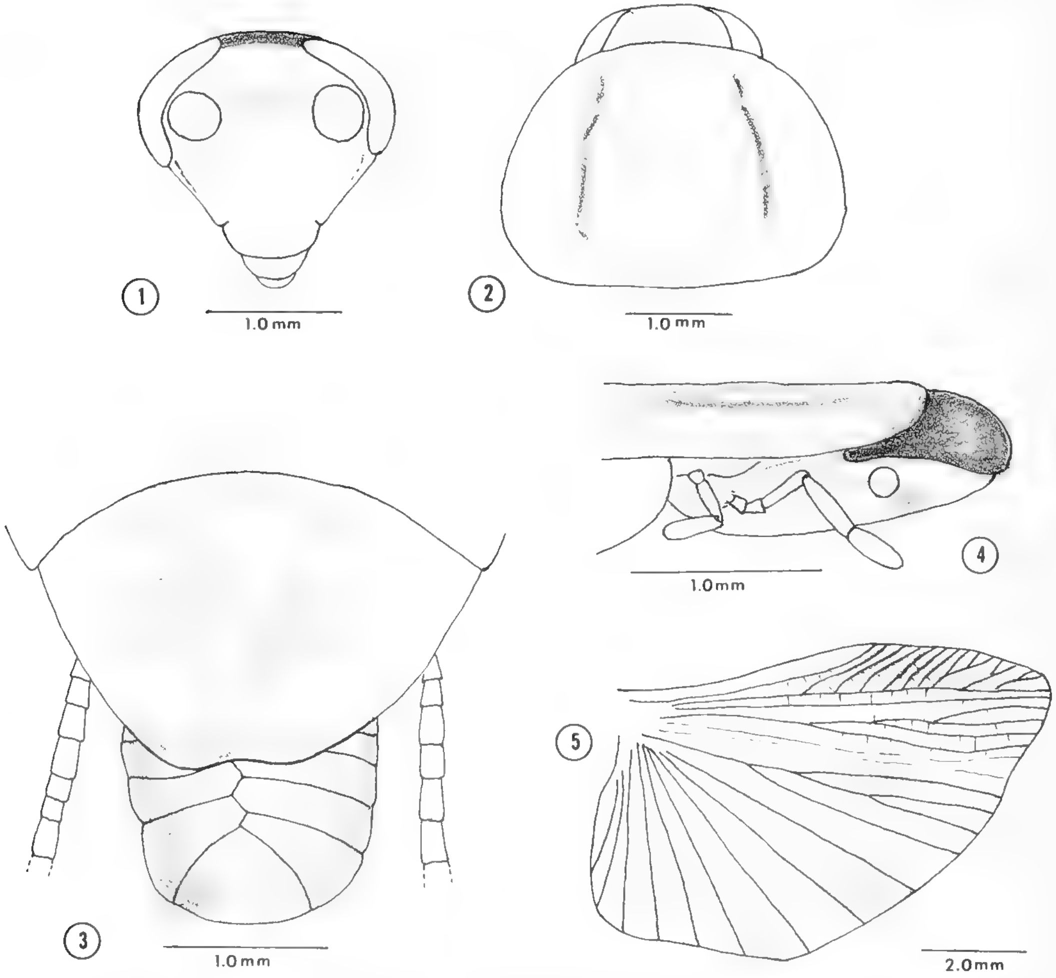
Type species by selection: *Blattella lineaticollis* Bolívar.

Etymology.—The name honors the late Dr. Eleanor H. Slifer (McIver 1987: 195), insect morphologist and colleague.

Description (♀ only; ♂ unknown).—Head triangular (Fig. 1), strongly flattened (Fig. 4). Tegmina and wings fully developed. Tegmina with discoidal vein unbranched, cubitus and median veins and their branches diagonal. Hind wing with discoidal and median veins simple, cubitus vein straight with complete branches, incomplete branches absent, apical triangle small (Fig. 5). Anteroventral margin of front femur with a row of piliform spinules terminating in 2 large spines (Type $C_2$); pulvilli present on 4 proximal tarsomeres, tarsal claws strongly asymmetrical, unspecialized, arolia present. Ovoviviparous; ootheca, not rotated, is retracted with eggs in original vertical position.

Comments.—Unfortunately, the male is unknown but needed to complete the generic description. The females are similar to *Balta* in front femur armament, tarsal claws, and wing venation. But, they can be distinguished from that genus by the strongly flattened triangular head, reminiscent of the Australian genus *Mediastinia* Hebard (1943: 9).

Only two species are known, the type species and a taxon I did not name because it differed principally only in color from *lineaticollis*. Both are described below.



Figs. 1–5. *Sliferia lineaticollis* (Bolívar). 1–4. Female holotype. 1, Head. 2, Pronotum. 3, Subgenital plate and protruding ootheca (ventral view). 4, Head and part of pronotum (lateral view). 5, Paratype, sex unknown, hind wing.

## *Sliferia lineaticollis* (Bolívar), New Combination

*Blattella lineaticollis* Bolívar, 1924: 327; Chopard, 1951: 143; Scott, 1933: 340; Princis, 1969: 1007 (sp. incertae sedis); Roth, 1985: 211 (sp. incertae sedis).

Material examined.—Holotype: Female (carrying an ootheca internally), Mahé, 1908-9 Seychelles Exp., Percy Sladen Trust Exped. Brit. Mus., 1926-203 (BMNH).

Paratype.—1 (terminal abdominal segments missing), same data as holotype (BMNH).

Male.—Unknown.

Female.—Interocular space about same as distance between antennal sockets (Fig. 1). Palpal segments 4 and 5 about equal, each longer than segment 3. Tegmina and wings extending beyond end of abdomen. Hind wing with costal veins weakly thickened distad; cubitus vein with 3 complete and no incomplete branches, apical triangle small (Fig. 5). Supraanal plate trigonal, apex weakly indented.

Measurements (mm).—Length, 9.3; pronotum length × width, 2.4 × 3.5; tegmen length, 9.5.

Coloration.—Head with occiput pale, a black transverse band on vertex then a whitish hyaline area and a broad, uneven, brown transverse band between antennal sockets, remainder yellowish brown (Fig. 1). Pronotal disk yellowish brown with narrow dark brown longitudinal lines demarcating it laterally, broad lateral regions hyaline (Fig. 2). Tegmina yellowish brown, hyaline, mediastine vein dark brown. Abdominal terga light yellowish brown with dark infuscation laterally on distal segments; terminal segments blackish brown; supraanal plate blackish with a dirty white transverse stripe basally, a similarly colored macula medially near apex. Abdominal sterna with yellowish brown lateral borders, remainder mottled brownish. Cerci dark brown on proximal segments becoming paler distad.

Ootheca.—The holotype is carrying a fully formed egg case in the upright position (keel region dorsad) inside the abdomen, with a small part of the ootheca protruding beyond the end of the abdomen (Fig. 3). The exposed keel region is flat and lacks raised respiratory serrations. Those eggs seen through the ventral hyaline regions of the oothecal membrane are apparently undeveloped.

Comments.—Scott (1933: 340) and Chopard (1951: 143) found this species in the axils of leaves of screw pines (*Pandanus* sp.) and the palm *Verschaffeltia splendida*.

The holotype was collected probably while she was ovipositing and had not yet retracted the ootheca completely into the brood sac. Or, she may have completed oviposition but partly extruded the egg case when she was killed. Several years ago (Roth 1985: 211) I noted that this female was carrying an ootheca but I incorrectly stated that it was rotated and I failed to point out that it was carried internally.

### *Sliferia* sp.
Figs. 6–8

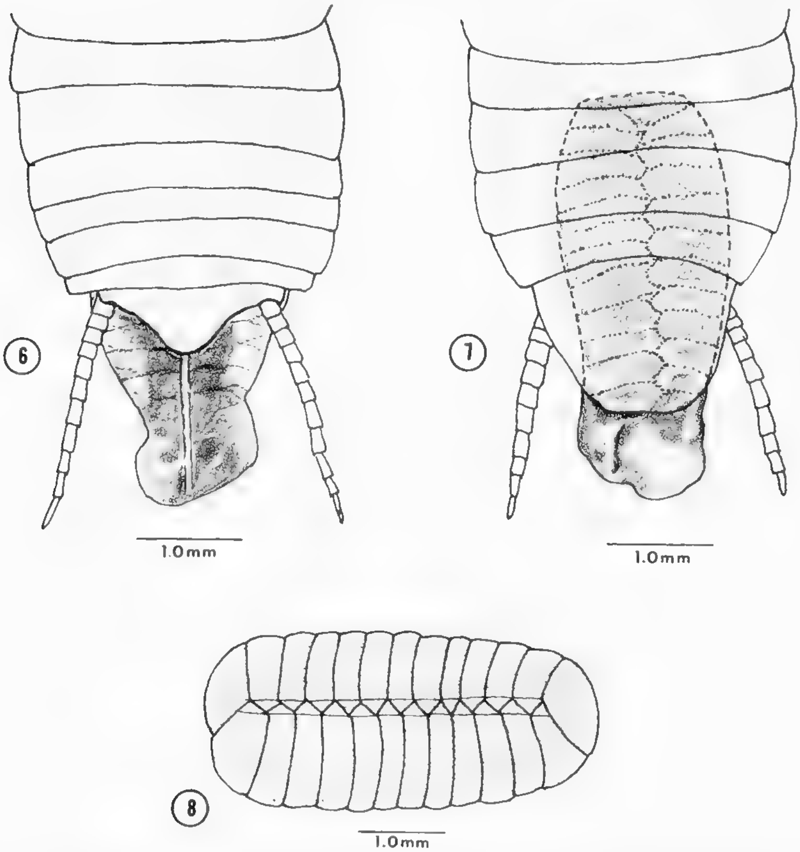
Material examined.—Seychelles, La Digue, 1 ♀ (carrying ootheca internally), 7.III.1953, E. S. Brown, presented by Comm. Inst. Ent. B.M. 1954-368, genitalia slide 264 (BMNH).

Female.—Head exposed, strongly flattened; palpal segments 3 and 4 equal, each slightly larger than segment 5; interocular space less than distance between antennal sockets. Tegmina and wings fully developed (glued together), extending beyond end of abdomen. Front femur Type $C_2$; pulvilli present on 4 proximal tarsomeres, tarsal claws strongly asymmetrical, unspecialized, arolia present. Supraanal plate trigonal, apex rounded (Fig. 6).

Measurements (mm).—Length, 9.9; pronotum length × width, 2.3 × 3.3; tegmen length, 9.2.

Coloration.—Head with occiput pale, hyaline; edge angular where vertex leads into flattened face, with a narrow, transverse brown line, then a colorless hyaline area and a small, poorly defined, light brown macula, rest of face pale. Pronotal disk yellowish, without markings, broad lateral regions hyaline. Tegmina almost colorless hyaline. Abdominal terga yellowish without dark markings. Abdominal sterna pale, in part hyaline. Cerci with ventral surface darker than dorsal, inner lateral edges of segments narrowly infuscated. Legs pale.

Ootheca.—The female was carrying an ootheca that was partially collapsed and protruding from the end of the abdomen. Most of the egg case could be seen through the hyaline parts of the abdominal sterna and it occupied a large part of the abdominal cavity (Figs. 6, 7). The ootheca was oriented with its keel region dorsad and was not rotated prior to being retracted into the brood sac. I placed the abdomen in 10% KOH for



Figs. 6–8. *Sliferia* sp., pregnant female from La Digue, Seychelles. 6, Abdomen (dorsal view). 7, Abdomen (ventral view; most of the internal ootheca is visible through the abdominal sterna). 8. Ootheca removed from abdomen and treated with KOH (dorsal view).

several minutes and the egg case floated out of the abdomen and swelled (Fig. 8). It was 4.5 mm long, wider than high, and contained 25 eggs, some of which showed early embryonic development. The oothecal membrane was thin, flexible, and completely covered the eggs. There were neither serrations (respiratory tubules) in the keel region, nor calcium oxalate crystals.

## Evolution of ovoviviparity and viviparity in the Blattaria

In the two phyletic lines of Blattaria, ovoviviparity and viviparity arose in the superfamily Blaberoidea but not in the Blattoidea. It was originally believed that ovoviviparity was found only in the Blaberidae (McKittrick 1964, Roth 1970). Recently it was discovered in an African genus *Stayella* Roth (Roth 1982a, 1984) (Blattellidae: Blattellinae), and now in *Sliferia* (Blattellidae: Pseudophyllodromiinae of Vickery and Kevan 1983: 157 = Plectopterinae of McKittrick 1964). Internal incubation of eggs by Blattaria evolved from oviparous ancestors (Fig. 9) and required changes in physiology, morphology, and oviposition behavior. The families and subfamilies shown in Fig. 9 are principally those of McKittrick (1964) except for the Nocticolidae and Attaphilinae which she did not study. I (Roth 1988: 300) discussed the

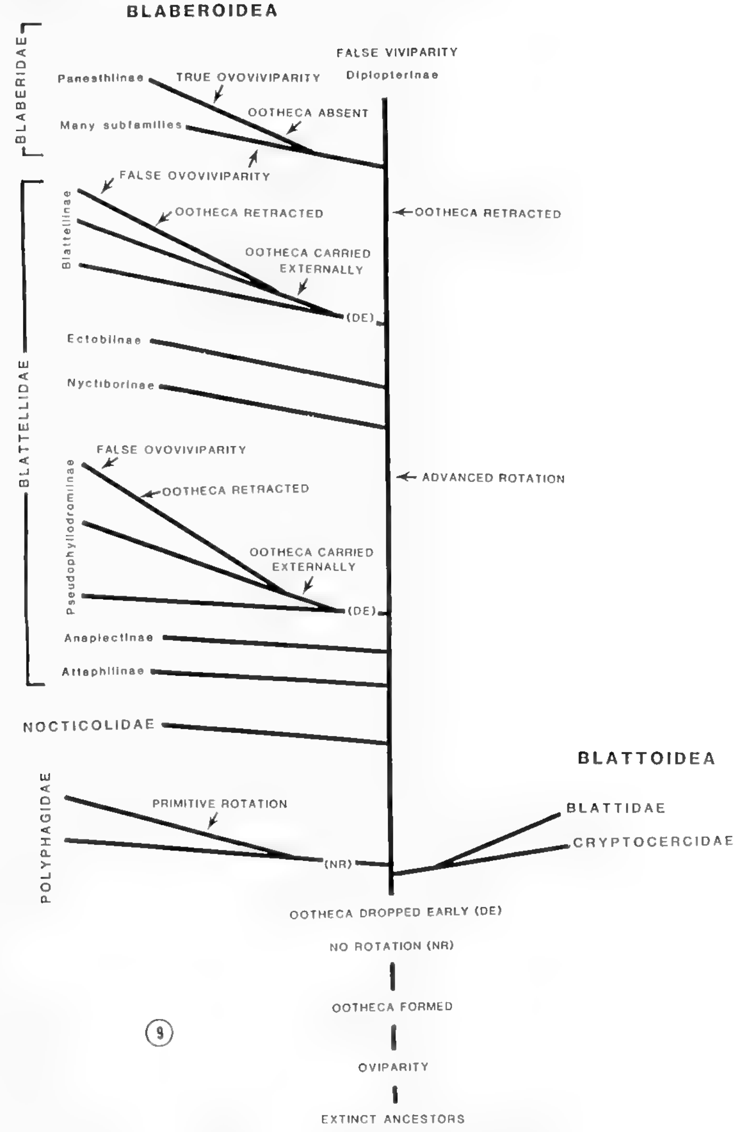


Fig. 9. Possible evolution of ovoviviparity and viviparity in the Blattaria.

taxonomic position of the former family and McKittrick (*in* Roth 1968c: 135) placed the Attaphilinae in the Blattellidae.

Extinct ancestors.—Vishniakova (1968) summarized the literature on fossil cockroaches. The oviparous females had external ovipositors and have been found in the Upper Carboniferous and Permian deposits of Europe, Asia, and North America, and in the Triassic and Jurassic deposits of the USSR. Presumably the species laid eggs singly in plants or soil. With time, the ovipositor was gradually reduced in length. Eventually a structure evolved hidden within the vestibulum that was used to form an ootheca containing a group of eggs. In some Jurassic species, the ovipositor is very short and the transition from long external ovipositors to short internal ones apparently took place towards the end of the Mesozoic.

Oothecae have been described from the Carboniferous, but the fossils only remotely resemble an egg case (Roth 1967b: Fig. 16), and most likely are imprints or fragments of other organisms (Brown 1957, Vishniakova 1968). An ootheca from the Eocene (Brown 1957, Roth 1967b: Fig. 15) appears to be an authentic blattellid egg case. McKittrick (1964) suggested that the primitive cockroach ootheca was probably a packet of eggs glued together like the ootheca of the termite *Mastotermes darwiniensis* Froggart (Roth 1967b: Fig. 17). Except for two genera (possibly four) of ovoviviparous Panesthiinae, cockroaches that have been studied produce an ootheca.

Selection pressure.—According to Vishniakova (1968) the selection pressure for the reduction of the external ovipositor and the change from oviparity to internal incubation of the eggs was the appearance in the Carboniferous to the Jurassic of predators and parasites that destroyed eggs. A number of Hymenoptera are known that destroy cockroach eggs (Roth and Willis 1960: 234–255). Some wasps can oviposit through a deposited and hardened ootheca. For example *Tetrastichus hagenowii* (Ratzeburg) lays eggs in oothecae of *Periplaneta americana* (Roth and Willis 1954b: Plate I). Other wasps can oviposit into the soft ootheca before the wall hardens. For example, *Evania appendigaster* (Linn.) lays eggs in the ootheca of *P. americana* (Kieffer 1912); *Zeuxevania splendidula* Costa into the oothecae of *Loboptera decipiens* (Germar) (Genieys 1924). *Anastatus floridanus* Roth and Willis oviposits through the soft walls of the egg case of *Eurycotis floridana* (Walker) while the ootheca is still carried by the female and before it hardens and is deposited (Roth and Willis 1954c: Fig. 9); the female often buries the ootheca in sand and once this is done the wasp usually can't locate it for oviposition. Oothecae still attached to females of *Blattella dethieri* Roth and *Blattella armata* (Princis) have contained a single evaniid wasp (Roth 1985: Figs. 92C, 102D, 102E). Schletterer (1889) found the evaniid *Brachygaster minutus* (Olivier) in the ootheca of *Blattella germanica* (Linn.). Wasps that parasitize the eggs of *Blattella* oviposit into the ootheca while it is carried by the female. The cockroach continues to carry the egg case while the eggs are being eaten by the parasitoid.

In classifying the placement of parasitic wasp eggs in relation to host species, Clausen (1972) erected the category: Egg placed in the embryo while the latter is still within the parent. Although this behavior was not known to occur, Clausen believed that it probably could occur. *Evania appendigaster* was claimed to parasitize the eggs of the blaberid *Leucophaea maderae* (Fab.) (Schletterer 1889, Bordage 1896, Kieffer 1912). But after realizing that *Leucophaea* is ovoviviparous, Bordage (1913) admitted misidentifying the parasitized ootheca and concluded that the developing eggs of *Leucophaea* are protected against egg parasites because they are carried within the female. Sells (1842) reported that an ootheca of *Leucophaea maderae* (= *Blaberus maderae*) contained ninety six specimens of a small chalcid wasp; some oothecae had a round hole through the side of the capsule from which the wasps had emerged. Sells statement that the ootheca had a keel with 16 dentations indicates that the parasitized oothecae probably were *Periplaneta americana* (Roth and Willis 1954b: Plate III).

It is true that eggs of ovoviviparous cockroaches have not been found to be parasitized by wasps. The oviposition of some wasps into an ootheca while it is still carried by the female is evidence that wasps that destroy the eggs of ovoviviparous species probably will be found. I suspect that wasp parasitoids will be found in species of *Stayella* with oothecae similar to those of *Blattella* but incubated internally. The *Stayella* ootheca could be parasitized as it is being formed and before it is retracted into the brood sac. If the female cockroach extruded the parasitized ootheca when the wasp matured, the adult parasite could easily escape the host abdomen. Similarly, the eggs of ovoviviparous Blaberidae could be parasitized while the ootheca was being formed before it was retracted into the uterus. Protection from wasp egg parasitoids could probably be assured if the eggs were never exposed to the outside, and this occurs only in true ovoviviparous genera *Macropanesthia* and *Geoscapheus.*

Laurentiaux (1951) suggested that the ootheca appeared as an adaptive response to climatic and hygrometric changes. The oothecal membrane in the Blattoidea is capable of preventing desiccation of the eggs even when exposed to very low humidities. In the Blattellidae, the protective covering varies in its ability to prevent water loss, and in the Blaberidae, the greatly reduced covering does not prevent the eggs from losing water even in very high humidities. These studies in water loss (Roth and Willis 1955b, Roth 1967b) indicate that an important selection pressure for the evolution of internal incubation was the prevention of egg death from water loss.

Ootheca formation.—Roth (1974) found that there has been a divergence of the centers that control oviposition in the Blaberoidea and Blattoidea. The brain is not needed for oviposition in the Blaberidae where the control center for formation, 90° rotation, and retraction of the ootheca into the brood sac probably lies in the last abdominal ganglion. In the Blattidae the brain is needed to initiate egg case formation, but it is unnecessary once the process has begun.

During oviposition, the female extrudes some colleterial gland secretion as a soft rubbery blob in a mold formed by the intersternal membrane of the vestibulum. As the eggs leave the gonopore they are guided by the ovipositor valves into the blob of secretion where, with micropylar ends dorsad, they line up, alternating sides, and protrude from the end of the abdomen as a double row (Roth and Willis 1954a: Pl. 5). In oviparous species the newly formed ootheca is pale and soft but hardens quickly when exposed to air. The dorsal ovipositor valves serve as a mold and impart characteristic shapes to the keel. Each egg lies in a cell surrounded by an air space connected to a duct in the keel that leads to external air. Oothecae of different species differ in size, shape, surface texture, keel serration, and the number of contained eggs (Roth, 1968b, 1971). Ovoviviparous species of Blaberidae and species of Blattellidae that carry their oothecae externally during embryogenesis generally have a larger number of eggs per ootheca but produce fewer oothecae than oviparous species that drop their egg cases shortly after forming them (Roth 1970: fig. 21).

The paired ovaries of cockroaches consist of a variable number of ovarioles. Each ovariole consists of a variable number of oocytes and at oviposition supplies one yolk-filled egg in the ootheca. Those oocytes containing yolk at oviposition are found in a region known as Zone V. Both the Blattoidea and Blaberoidea probably evolved from taxa in which three or more oocytes contained yolk in Zone V. In the Blaberoidea there is an evolutionary trend towards a decrease in the number of oocytes in Zone V, as well as the total number of oocytes per ovariole. The Polyphagidae have two or three oocytes in Zone V, and a large number of oocytes per ovariole. Species of Blattellidae have one or two oocytes in Zone V, and show some reduction in total number of oocytes. In ovoviviparous and viviparous Blaberidae there is a marked reduction in the number of oocytes, and only one oocyte develops yolk at oviposition. Species like *Blattella* that carry their oothecae externally during embryogenesis have only one oocyte in Zone V and few oocytes per ovariole as in most Blaberidae (Roth 1968c).

During pregnancy in ovoviviparous and viviparous taxa, the corpora allata are inhibited and yolk deposition does not occur in the oocytes as long as there is an ootheca in the uterus. Yolk inhibition also occurs in pregnant *Blattella.* In ovoviviparous taxa the colleterial glands show cyclical activity corresponding to the ovarian cycle: active during the preoviposition period, inactive during gestation, and active again after parturition (Roth 1968b). In oviparous species that drop their oothecae early, the colleterial glands secrete protein continuously, there is no distinct cycle related to oviposition, and during the height of their reproductive period females produce oothecae frequently.

In oviparous species, a hardened ootheca is carried externally for various lengths of time. It can be deposited shortly after its formation or retained for the full gestation period (Roth and Willis 1958: figs. 1–12, 30–37). When first deposited the eggs may have sufficient water and yolk to complete development (Blattidae), or they have sufficient yolk but require water which is obtained from the female (*Blattella* spp., *Lophoblatta* spp.) or from the substrate (most Blaberoidea, except Blaberidae) (Roth 1967b, 1968a, Roth and Willis 1955b).

Once the ootheca is formed, the female may oviposit in one of the following ways:

No rotation, ootheca dropped early (NR).—The original vertical position of the ootheca is not changed and the egg case is deposited shortly after its formation (Roth and Willis 1954a: Pl. 5). The female may try to hide the dropped egg case by burying it or covering it with a mixture of saliva and chewed substrate, and then she abdandons it (McKittrick 1964). Examples are Nocticolidae (Chopard 1932: 489), some species of Polyphagidae, Blattellidae (Attaphilinae, Anaplectinae, many genera of Pseudophyllodromiinae), all species of Blattidae and Cryptocercidae (Roth 1968b).

Ootheca carried externally during gestation.—These oviparous species carry their oothecae attached to the end of the abdomen until the eggs hatch. The ootheca can be held in the original vertical position as in *Lophoblatta* (Roth 1968a) or rotated 90° as in *Blattella* (Roth and Willis 1958: Pl. 25, figs. 7–12, Pl. 27, figs. 29–37).

Primitive rotation.—The ootheca is rotated 90° and deposited shortly after its formation. The egg case has a flange which is held by the paraprocts and none of the anterior eggs are held within the vestibulum in contact with the tissues of the female (Roth 1970: fig. 5). Primitive rotation is known only in some Polyphagidae, including *Arenivaga* (*Arenivaga*) spp. (Roth 1967a) and *Latindia* sp. (Roth 1971: 128).

Advanced rotation.—After the ootheca is formed and still attached, it is rotated 90° so the keel is lateral, to the left in Blaberidae, and the right in most Blattellidae. Several of the most anterior eggs, those leaving the oviduct last, are in contact with the vestibular tissues of the female. This contact is necessary for oviparous species like *Blattella* spp. and *Lophoblatta* spp. whose eggs obtain water from the mother during embryogenesis (Roth 1967a). Examples are Nyctiborinae, Ectobiinae, most Blattellinae and Pseuphyllodromiinae, and all Blaberidae that form an ootheca.

Oothecal changes.—During the evolution of ovoviviparity in the Blattellidae, changes in the ootheca involved reduction in height of the keel and finally loss of the keel, and softening of the increasingly flexible protective membrane due to the gradual reduction and finally loss of calcium oxalate crystals. The oothecal changes in the Blaberidae were greater than those that took place in the Blattellidae (*Blattella, Stayella, Sliferia*). In some blaberids the oothecal wall is relatively thick and covers the eggs completely. In others, the wall shows various degrees of reduction and does not cover the micropylar ends of the eggs. Although the keel is absent in most blaberids, relicts of this structure occur in *Epilampra cribrosa* Burmeister (Roth 1968b), for example.

Ootheca retracted.—After the ootheca is formed, it is retracted into the brood sac with or without being first rotated 90° (Roth and Willis 1954a: figs. 74–79, 86–90).

McKittrick (1964: 116) believed that rotation of the ootheca freed the keel from the ovipositor valve bases, which supposedly block anterior movement of the vertical ootheca. But, as noted above, in the Blaberidae the ootheca is reduced, keel serrations are absent or rarely subobsolete so rotation is not necessary to free its keel from the valve bases (Roth 1967a). In the blattellid *Sliferia* the ootheca lacks keel serrations and is retracted in the vertical position.

In the ovoviviparous Blaberidae, the eggs enlarge in the brood sac during embryogenesis (Roth and Willis: 1955b, fig. 7A–D). When stretched by a newly deposited ootheca, the blaberid uterus presses against the inner surfaces of the terga and sterna and leaves room laterally for expansion (Roth 1967a: 85). Just before parturition the ootheca occupies practically the entire abdomen (Roth 1967a: 85). But even at this time it is difficult to determine if the female is pregnant because the abdomen hasn't stretched as much as it would have had the ootheca been retracted into the uterus in the vertical position. To determine pregnancy one has to separate the supraanal and subgenital plates and look for the terminal end of the ootheca. Cockroaches generally are relatively flat insects and tend to hide in narrow crevices and spaces where they can escape from predators. It is advantageous for the eggs to be so oriented in the uterus that their increase in size does not markedly increase the height of the abdomen. In *Blattella* rotating the ootheca allows the insect to hide in narrower crevices than would be possible if the ootheca was carried externally in the vertical position. Wille (1920) measured the minimum gaps within which various stages of *B. germanica* could move. Gravid females 1 day before oviposition needed a space of 4.5 mm; with the ootheca in the vertical position, the width decreased to 3.3 mm, and after the egg case was rotated the female could move in a space 2.9 mm high. In *Sliferia,* the eggs probably do not increase much in length during embryogenesis and because its ootheca is wider than high rather than higher than wide, rotation is not necessarily advantageous and the ootheca is retracted in the vertical position.

False ovoviviparity.—The ootheca is formed and retracted into the brood sac. Initially the eggs have enough yolk to complete development but must obtain water from the female during embryogenesis. The marked similarity of the oothecae of *Stayella* and *Blattella* (Blattellinae), and *Sliferia* and *Lophoblatta* (Pseudophyllodromiinae), strongly suggests that the ancestors of the two ovoviviparous genera were *Blattella*-like and *Lophoblatta*-like species in their respective subfamilies. Cockroaches with false ovoviviparity include two genera in the Blattellidae, and all Blaberidae except two truly ovoviviparous genera, and one viviparous species.

True ovoviviparity.—No ootheca is formed. During oviposition the eggs are never exposed to the outside but pass directly into the vestibulum and brood sac where they lie in a jumbled mass. At oviposition the eggs have enough yolk to complete development, and take up only water from the mother during embryogenesis (Rugg and Rose 1984a). Examples include *Macropanesthia rhinoceros* Saussure, *Geoscapheus dilatatus* (Saussure), and probably species of *Neogeoscapheus* and *Parapanesthia.* All four of these genera were originally placed in the Panesthiinae, tribe Geoscapheini (Roth 1982b), but because of the absence of an ootheca Rugg and Rose (1984b) placed them in the family Geoscapheinae.

Roth (1968b: 103) speculated that complete loss of the oothecal membrane would result in eggs being simply glued together in a double row, presumably like the ootheca of *Mastotermes darwiniensis,* and then could be retracted into the brood sac. Rugg and Rose's discovery shows that some species can deposit their eggs in the uterus without first extruding them in a double row.

False viviparity.—The ootheca is very small, containing about a dozen eggs, and has an incomplete covering membrane (Roth and Hahn 1964). Because of their small size, hardly any of the eggs are seen during oviposition, but the ootheca is rotated and retracted into the brood sac. Initially the eggs lack sufficient yolk and water to complete development (Roth and Willis 1955a). During embryogenesis the embryos drink water and dissolved proteins and carbohydrates, synthesized and transported by the brood sac (Stay and Coop 1973, 1974, Ingram et al. 1977). *Diploptera punctata* (Eschscholtz) is the only known example, although other species in the genus probably have the same type of reproduction.

True viviparity.—No example in cockroaches is known. In true viviparity, the eggs would pass directly into the brood sac without first being exposed externally, and they would obtain solids and water from the female during embryogenesis.

The discovery that ovoviviparity occurs in two subfamilies of Blattellidae rather than only in the Blaberidae as proposed by McKittrick (1964) does not contradict her basic thesis that ovoviviparity arose only in the Blaberoidea and not in the Blattoidea. In this regard there is no reason to revise McKittrick's system.

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# A NEW SPECIES OF *DASYHELEA* MIDGE REARED FROM DRAINS IN SINGAPORE (DIPTERA: CERATOPOGONIDAE)

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*Abstract.*—Male and female adults, pupae and larvae of ***Dasyhelea schizothrixi*** new species are described from material collected from free-flowing open-channel concrete drains in Singapore. Diagnostic characters are given to distinguish *D. perfida, D. laeta,* and *D. bullocki* from the new species.

*Key Words:* *Dasyhelea schizothrixi,* open concrete drains, *Schizothrix* algae

Biting midges of the genus *Dasyhelea* Kieffer are common and widespread in all regions of the world. The aquatic or semiaquatic larvae are found in various habitats that have at least a thin film of water in which the larvae can survive. The larvae are poor swimmers and slowly climb or push through the substratum by using their mouthparts and posterior anal hooks. Their preferred habitats include wet moss or algae along the shores of streams, lakes, ponds, puddles and other water bodies, or wet rotting plant materials such as sap from trees, wet bark, and tree holes. Some species inhabit rock pools, hot springs, or water with high mineral content. Others have colonized the intertidal zone along algae-covered rocks or algae growing on mud exposed to tidal action in salt marshes.

Adult *Dasyhelea* midges are usually found near breeding sites. Shrubs, plants near water, and flowers are favorite resting places of some species. Their feeding habits are little known but some have been found feeding on nectar from flowers and extrafloral nectaries, honeydew, and sweet secretions from plants (Downes and Wirth 1981). None are known to be bloodsuckers. Some species are important pollinators of *Theobroma cacao, Hevea brasiliensis,* and other tropical tree crops.

This is the first record of a *Dasyhelea* from free-flowing open-channel concrete drains in a city. The drainage system was implemented for the control of Anopheline mosquitoes through the removal of all surface water larval habitats. The midge larvae were found living in *Schizothrix* algal beds growing on these drains.

Eggs, larvae, and pupae were collected from the drains by removing a portion of the *Schizothrix* algal bed with a blunt scalpel. Larvae and pupae were killed in hot water and preserved in 70 percent ethanol. Egg masses were allowed to hatch and the larvae were individually reared through to adulthood in the laboratory. Twenty-four hours after emergence, the adults were killed by immersion in 70 percent ethanol, and transferred to glass microvials with the pupal exuviae for storage in 70 percent ethanol. Adults were dissected and mounted on slides according to the methods of Wirth and Marston (1968) and Lee and Chan

(1985). Terminology follows that given by Waugh and Wirth (1976) and Downes and Wirth (1981).

### *Dasyhelea schizothrixi* Lee and Wirth, New Species
Figs. 1–13

Male holotype.—Wing length 1.06 mm; breadth 0.37 mm; costal ratio 0.50.

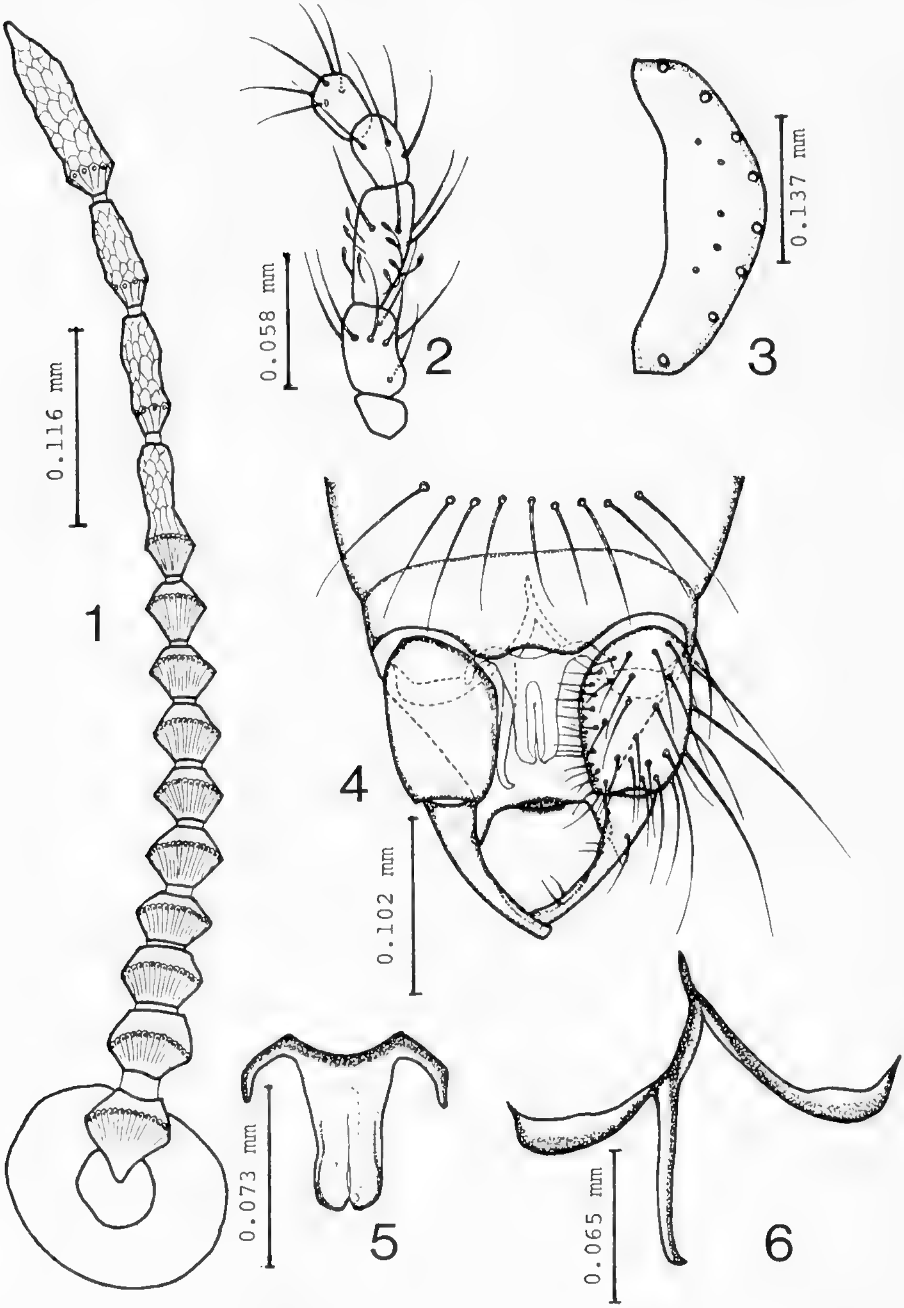
Head.—Brownish, proboscis and palpi stramineous. Eyes with fine pubescence. Antenna (Fig. 1) with lengths of flagellar segments in proportion of 40-30-30-28-27-25-25-25-25-52-55-50-82, antennal ratio (segments 12-15/3-11) 0.98; proximal segments not fused; with dense long brown plume setae; segment 12 binodose, 13 slightly so, 15 with long terminal papilla; all segments sculptured. Palpus (Fig. 2) moderately stout, with 14 club-shaped sensilla; lengths of segments in proportion of 28-38-23-25; palpal ratio 1.5.

Thorax.—Brownish; two pale longitudinal lines following the well-defined double series of dorsocentral setae; double line of acrostichal setae well defined, lateral setae scattered. Scutellum (Fig. 3) with eight large marginal setae and five smaller ones on disc. Legs stramineous, knee spots blackish; femora with narrow, faintly brownish bands just past midlength, fore tibia with a faint brown band at midlength and narrow brown apex; sparse vestiture of slender setae; tibiae with bristly setae; fifth tarsomeres brownish. Wing membrane whitish, radial veins slightly infuscated; first radial cell not formed, second radial cell faintly indicated by obscure thickening of veins, apex of cell truncated; macrotrichia long and slender, decumbent, moderately sparse, forming rows along veins and on membrane on proximal 0.7 of wing; bare linees between rows of macrotrichia. Halter deeply infuscated.

Abdomen.—Brown without segmental bands; sparse vestiture of long slender brown setae in transverse rows. Genitalia (Fig. 4): Ninth sternum slightly broader and slightly bilobate in midportion; ninth tergum slightly broader than long, markedly tapering distally to a pair of well-developed apicolateral processes. Gonocoxite slightly bulbous, stout, about 1.5 times longer than broad, without mesal hooklike process; gonostylus slightly longer than gonocoxite, stout proximad, tapering at midportion to slender, slightly arcuate, blunt-tipped distal portion. Aedeagus (Fig. 5) dark brown, slightly broader at base than total length, bearing a narrow bisinuate transverse sclerite proximally and a pair of elongate, pillar-like submedian processes caudally with bases narrowly joined and with a transparent membrane between except at extreme apex. Parameres (Fig. 6) heavily sclerotized, brownish, asymmetrical; basal apodemes unusually slender, the posterior process also slender in its entire length, slightly curved, extending caudad nearly to tip of ninth tergum.

Female allotype.—Wing length 1.00 mm; breadth 0.44 mm; costal ratio 0.56.

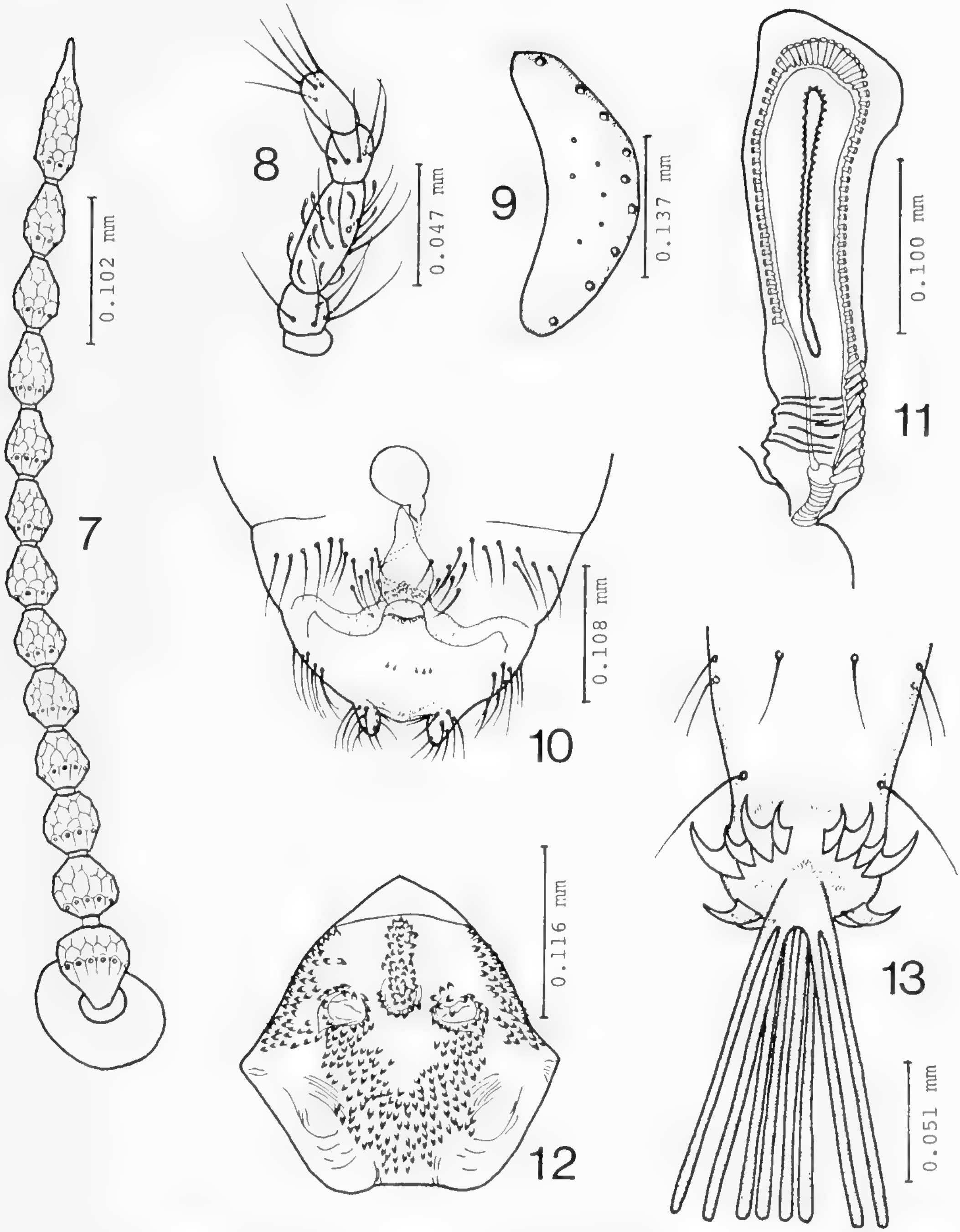
Similar to male with usual sexual differences. Antenna (Fig. 7) with lengths of flagellar segments in proportion of 34-30-30-30-30-30-30-30-32-34-35-35-60, antennal ratio (11-15/3-10) 0.80; segments ovoid, slightly attenuated distally; last segment with long terminal nipple as in male; all segments with definite sculpturing. Palpus (Fig. 8) stouter than in male, with 17 club-shaped sensilla; lengths of segments in proportion of 16-36-17-24, palpal ratio 1.4. Scutellum (Fig. 9) with nine large marginal setae and six smaller ones on disc. Wing with membrane dusky and veins more brownish than in male, second radial cell with oblique apex; macrotrichia slightly more numerous than in male, shorter and stiffer. Abdomen brownish, especially on pleural membrane which is dark brown and shagreened; setae scattered and dense on pleura. Genital sclerotization (Fig. 10) characteristic of the *grisea* species group with sinuate caudolateral arms on each side of gonopore and evenly tapering anteromedian lobe. Spermatheca



Figs. 1–6. *Dasyhelea schizothrixi* (male): 1, antenna; 2, palpus; 3, scutellum; 4, genitalia, ventral view; 5, aedeagus; 6, parameres.

single, pyriform with neck tapering and slightly oblique; measuring 0.072 by 0.055 mm including neck portion.

Pupa.—Length 2.06 mm. Dorsum of cephalothorax dark brown; degree of pigmentation on abdomen fainter posteriorly. Integument shagreened with minute tubercles that are coarse and thornlike on ceph-



Figs. 7–13. *Dasyhelea schizothrixi*; 7–10, female; 11–12, pupa; 13, larva: 7, antenna; 8, palpus; 9, scutellum; 10, genitalia, ventral view; 11, respiratory horn; 12, operculum; 13, last abdominal segment, ventro-posterior view.

alothorax, particularly on operculum (Fig. 12); setae poorly developed. Respiratory horn (Fig. 11) 0.30 mm long, transversely ridged, marginally expanded and slightly curved distally; outer edge of base with eight large spiracles; 67 (60–72) small spiracles form a dorsal loop near margin of respiratory horn; dorsal slit 0.16 mm long. Abdominal segments each with a ring of low scale-like tubercles near posterior margin, most of these tubercles with a minute transparent seta. Last abdominal segment with two dorsal and two ventral lobes; dorsal lobe with large dorsal spine and lateral spine; ventral lobe stout and blunt in female but tapering posteriorly in male pupa.

Larva.—Length 4.70 mm in fourth instar. Head capsule dark brown with two conspicuous black pigment spots; body milky except for slight brown pigmentation on dorsum. Head and body setae inconspicuous, few. A pair of distinct, internal, brownish pigment spots in each of the first two thoracic segments. Terminal abdominal segment (Fig. 13) with two pairs of slender hooks dorsally, four pairs of slender hooks ventrally; each pair of hooks consists of one small and one large hook; a band of slender spicules immediately anterior to hooks. Rectal gills grouped into two pairs dorsally and two pairs ventrally.

Distribution.—Singapore.

Types.—Holotype male, allotype female; Kent Ridge, Singapore, 2.x.1985, K. M. Lee, reared from concrete drains with *Schizothrix* algae. Paratypes: 9 males, 7 females, 4 larvae, 10 pupae, same data, but dates 16.v–8.ix.1984. Holotype and allotype specimens are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. Paratypes are deposited in the Australian National Collection, Canberra; B. P. Bishop Museum, Honolulu, Hawaii; British Museum (Natural History), London; Museum National d'Histoire Naturelle, Paris; and Zoological Reference Collection, National University of Singapore, Singapore.

Discussion.—*Dasyhelea schizothrixi* belongs to a large group of closely related species that characteristically breed in rock holes or in drains, roof gutters, or similar habitats. The group includes *D. carolinensis* Tokunaga (1941) from the Caroline Islands, *D. hitchcocki* Wirth (1976) from the Tonga Islands and Samoa, *D. laeta* (Johannsen) (1931) from Sumatra, *D. perfida* (Johannsen) (1931) from East Java, *D. pseudoincisurata* Waugh and Wirth (1976) from the southeastern United States, *D. saxicola* Edwards (1929) [synonym *D. lithotelmatica* Strenzke (1956)] from Europe, *D. sublettei* Wirth (1987) from the southwestern United States, *D. thompsoni* de Meillon (1936) from Transvaal, *D. tugelae* de Meillon (1936) from Natal, and *D. upsilon* de Meillon and Wirth (1987) from Transvaal.

According to its incomplete original description, *Dasyhelea perfida*, described from water-sprayed leaves of *Colocasia indica* near a waterfall, closely resembles *D. schizothrixi*. *Dasyhelea perfida* has a yellowish thorax with brownish vittae; yellow unbanded legs; body length of 1.2 mm, and a whitish halter with darker stem. The female has large brownish spots on the intermediate pleura of the abdomen. The male genitalia are nearly identical with those of the new species except that the ninth sternum is not bilobed and the posterior process of the parameres is distinctly bent backwards at the tip. According to Mayer (1934) the pupal respiratory horn of *D. perfida* differs from that of *D. schizothrixi* in having a loop of 49 spiracles around the margin of the distal half (similar in arrangement to many species of the genus) and eight spiracular openings on the transversely ridged basal portion.

Tokunaga and Murachi (1959) apparently incorrectly redescribed *Dasyhelea perfida* from misidentified Micronesian material. Their species differs from *D. perfida* in the male genitalia: the apicolateral processes on the ninth tergum are blunt; the aedeagus has four distinct posterior processes, and the posterior process of the parameres is broadly expanded distally and has a blunt distal point.

*Dasyhelea laeta,* reared from rock pools in Sumatra, differs from *S. schizothrixi* in its larger size (male body 2 mm, female 1.75 mm); in its shining dark brown mesonotum with four darker brown vittae; in its pale halteres, and in its brownish legs with under sides of the femora yellowish and the tips of the femora with preapical whitish rings. In *D. laeta,* the pupal respiratory horn has coarse scales on most of the midportion, 10 spiracles in a loop at the extreme tip, and five widely spaced spiracles on the basal portion.

*Dasyhelea bullocki,* from a rock hole near a stream in Korea, belongs to the same group as the new species, but differs in its more distally attenuated antennal segments; in its spermatheca with elongate oblique neck; in its male genitalia with a stout, tapering, posterior process on the parameres, and in its single loop of spiracular openings on the pupal respiratory horn.

Five closely related species that breed in the pitchers of *Nepenthes* are more distantly related to this group of species, differing in details of the pupal respiratory horn, male genitalia, and in the more elongate, bent neck of the spermatheca. This group of species includes *D. ampullariae* Macfie (1934) from Malaysia, *D. biseriata* Wirth and Beaver (1979) from Malaysia, *D. confinis* (Johannsen) (1931) from Sumatra, *D. nepenthicola* Wirth and Beaver (1979) from Malaysia, and *D. subgrata* Tokunaga (1961) from West Irian.

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PROC. ENTOMOL. SOC. WASH.
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# A NEW SPECIES OF *NEOBAPHION* BLAISDELL, FROM IDAHO (COLEOPTERA: TENEBRIONIDAE)

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*Abstract.*—***Neobaphion alleni***, a new species from Idaho, is described and illustrated. *Eleodes* (*Metablapylis*) *insolitus* Doyen is made a synonym of *Neobaphion papula* Triplehorn and Aalbu.

*Key Words:* Tenebrionidae, Darkling Beetle, *Neobaphion*

For almost 50 years the genus *Neobaphion* consisted of only two species, *N. planipenne* (LeConte 1866) and *N. elongatum* Blaisdell (1933). In 1985, a third species, *N. papula* Triplehorn and Aalbu was described. The following new species was discovered only a few months after the description of *N. papula* was published:

## ***Neobaphion alleni***, New Species

Fig. 1

*Holotype, female:* Length: 15.2 mm; width: 7.0 mm. Body stout, subopaque, black.

Head subquadrate, $\frac{6}{7}$ as long as broad, flattened; clypeal suture entire but weakly defined, epistomal margin truncate; surface dull with numerous fine, rounded tubercles, each bearing a short, dark colored seta apically; eyes narrowly reniform with dorsal lobe larger, more rounded than ventral lobe; antennae short, stout, apical 6 segments moniliform; relative lengths of antennal segments (from base to apex): 10:4:18:10:9:8:8:8:8:9:10.

Pronotum $\frac{5}{6}$ as long as broad, broadest in anterior half, with a faint transverse crease in basal fifth; in dorsal view, lateral margin strongly arcuate and distinctly explanate, especially medially, marginal bead narrow and finely denticulate from base to apex; anterior margin broadly and evenly concave from side to side, angles acute, prominent; base nearly straight, angles obtuse; disc feebly convex, surface with tubercles similar to those of head but larger, shiny, densely and uniformly distributed, each with a short, brownish seta originating on caudal side.

Scutellum triangular, acute caudally, finely sculptured.

Elytra moderately convex from side to side, lateral margins subparallel, widest behind middle, abruptly deflexed posteriorly with pronounced caudal lobe; base slightly concave with humeri obsolete; surface with dense conspicuous shiny tubercles on disc similar to those of pronotum and with larger, denser and more spiculiferous tubercles laterally, each with a short, pale seta directed caudad.

Legs moderate in size, finely, densely, muricately punctate; profemur slightly emarginate subapically; protibial spurs about equal in size; basal protarsomere with dense tuft of golden setae interrupting plantar grove.

Ventral surface alutaceous with coarse, dense tubercles on hypomera and prosternum and basal 4 abdominal sterna, less coarse but equally dense on meso- and metasterna, with smaller and scarcely evident tubercles on apical sternum; prosternal

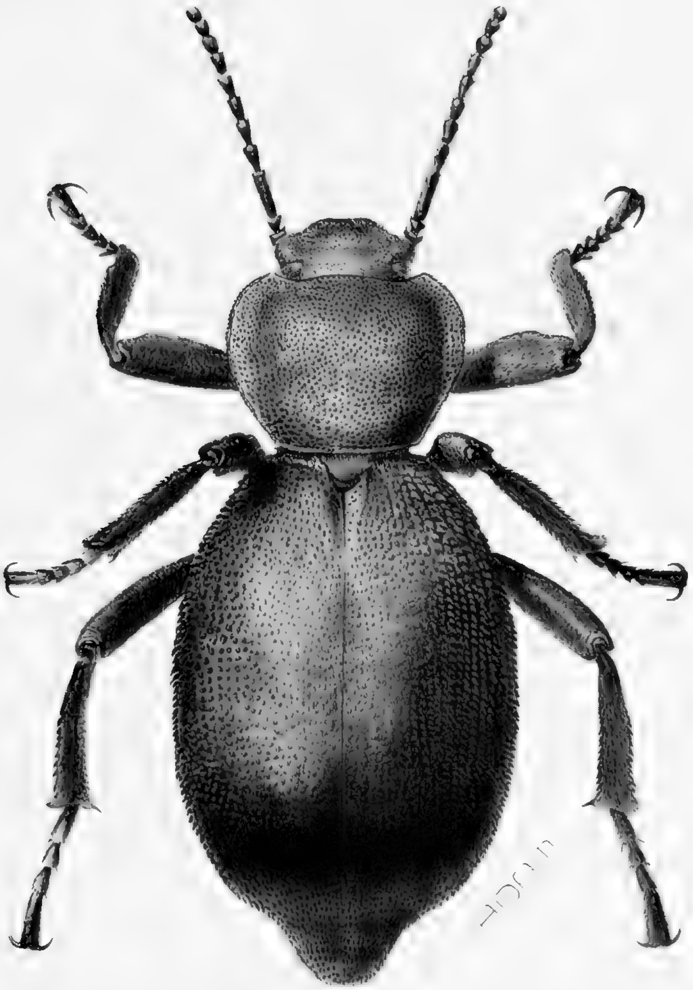

Fig. 1. Adult *Neobaphion alleni* n.sp. 6.7×.

process acute, horizontal. Genital segment with coxites fused, coxites 1 and 2 triangular in outline and concave ventrally, convex dorsally, coxite acute apically; gonostyle minute with single long apical seta.

*Allotype, male:* Similar to female but slightly smaller and more slender; Length: 13.0 mm; width: 5.7 mm.

Variation.—There is little variation among the five specimens available. The allotype male is the smallest and the paratype from Oregon is the largest (L: 17.8 mm; W: 7.8 mm).

Diagnosis.—*Neobaphion alleni* closely resembles *N. papula* and will run to that species in our key (Triplehorn and Aalbu 1985, p. 591). It may be readily separated from the latter by the explanate lateral margins of the pronotum and the lack of an elytral sutural "keel." In addition, the subapical emargination of the profemur, scarcely evident in *N. alleni,* is very pronounced in both sexes of *N. papula.* The genitalia of both sexes appear identical in the two species.

Types.—*Holotype, female:* IDAHO: Owyhee County, Brunneau Dunes, 14 April 1986, Albert Allen; *allotype male,* same locality, 18 May 1986, Albert and Kip Allen; *paratypes:* female, same locality, 13 May 1986, Albert Allen; (probably male), IDAHO, Ada County, 14 miles S. of Kuna, 15 April 1978, R.C. Biggam; female, OREGON [Malheur County], 32 miles SW of Vale, Twin Springs, 2 April 1969, Kenneth Goeden. Holotype in California Academy of Sciences, allotype in personal collection of Albert Allen, paratypes in University of Idaho, The Ohio State University and Oregon Department of Agriculture Collections.

Etymology.—I take pleasure in naming this species for Albert Allen who sent me the first specimen, made special efforts to collect more, and provided valuable ecological data.

Discussion.—Albert Allen has provided interesting collection data on the three specimens he captured. All were dug from rodent burrows (probably kangaroo rat) at the base of sagebrush plants on sand dunes by Mr. Allen and his son Kip. One was found along with two specimens of *Eleodes armatus* LeConte and one in company with *E. longipilosus* Horn, a common species on Brunneau Dunes. Mr. Allen has collected intensively in those dunes over 10 years but had never encountered this *Neobaphion* until 1986. Despite diligent efforts by the Allens, they obtained only two more specimens. Obviously, it is a rare beetle or it has been overlooked by individuals using conventional collecting techniques.

It seems appropriate at this time to point out an unusual circumstance involving synonymy in *Neobaphion.* In 1985, Doyen (p. 230) described *Eleodes* (*Metablapylis*) *insolitus* from Esmeralda County, Nevada. Also, in 1985, our paper (Triplehorn and Aalbu), describing *Neobaphion papula,* from Mineral County, Nevada, was published. The journals in which the two descriptions appeared were both mailed on 11 July 1985, thus constituting simultaneous publication. As the next reviser (this paper) I arbitrarily select *Neobaphion papula* Triplehorn and Aalbu as the valid name and am placing *Eleodes insolitus* Doyen as a synonym of it.

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# *POLYMERUS CASTILLEJA*, A NEW MIRINE PLANT BUG FROM CALIFORNIA AND OREGON, WITH REMARKS ON GENERIC CHARACTERS OF THE GENUS *POLYMERUS* HAHN (HETEROPTERA: MIRIDAE)

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*Abstract.*—The new species, ***Polymerus castilleja***, is described and distinguished from other *Polymerus* species. A male dorsal habitus and illustrations of the genitalia of both sexes are presented. The small hyaline right paramere and the deeply cleft secondary gonopore of the male genitalia, and the obsolete dorsal structure and median process of the female genitalia are perceived to be synapomorphic for species of the genus *Polymerus*.

*Key Words:* Heteroptera, Miridae, *Polymerus*

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Curation of the *Polymerus* Hahn holdings in the collections of the American Museum of Natural History revealed 115 specimens of a previously undescribed species. All the specimens of this taxon were taken from localities in California and Oregon on Indian paintbrush, and possessed marked sexual dimorphism and enlarged claw bases.

All measurements are in millimeters. A list of abbreviations of the specimen depositories are in the Acknowledgments.

### ***Polymerus castilleja***, New Species
Figs. 1–11

Diagnosis.—Distinguished from all other *Polymerus* species by the enlarged claw base (Figs. 2, 3).

Description.—Male. **Dorsal aspect.** Figure 1. Total length 4.40–5.40, length from apex of tylus to cuneal fracture 3.10–3.90; coloration variable, ranging from—dark specimens with head, antenna, pronotum, mesoscutellum, scutellum, clavus, anterior half of embolium, distal two-thirds of corium interiad of radius, and paracuneus black, with frons mesially, vertex mesially and contiguous with eye, carina entirely, scutellum apically, embolium distally, distal one-third of corium mesad of radius, corium laterad of radius, cuneus, and veins of membrane testaceous to light fuscous; to—light specimens with base color orange or red testaceous with dark color restricted to tylus, lora, juga apically, frons with 'U' shaped marking mesially, temporal area peripherally, collum, first antennal segment apically and basally, second segment apically, callus and posterior lobe of pronotum diffusely, mesoscutellum mesially and laterally, small basomedial dash on scutellum, clavus interiad of claval vein, corium diffusely distally between cubitus and radius and membrane; vestiture with golden, recumbent, sericeous setae, and black, suberect, simple setae on corium and cuneus distolaterally; surface structure smooth, except for weak to moderately transversely rugulose pronotum and scutellum. **Head.** Triangular in dorsal view; Width across eyes 0.95–1.00, interocular width 0.41–0.43; tylus produced, anteocular length 0.30–0.33; antennal fossa contiguous with eye; eye large,

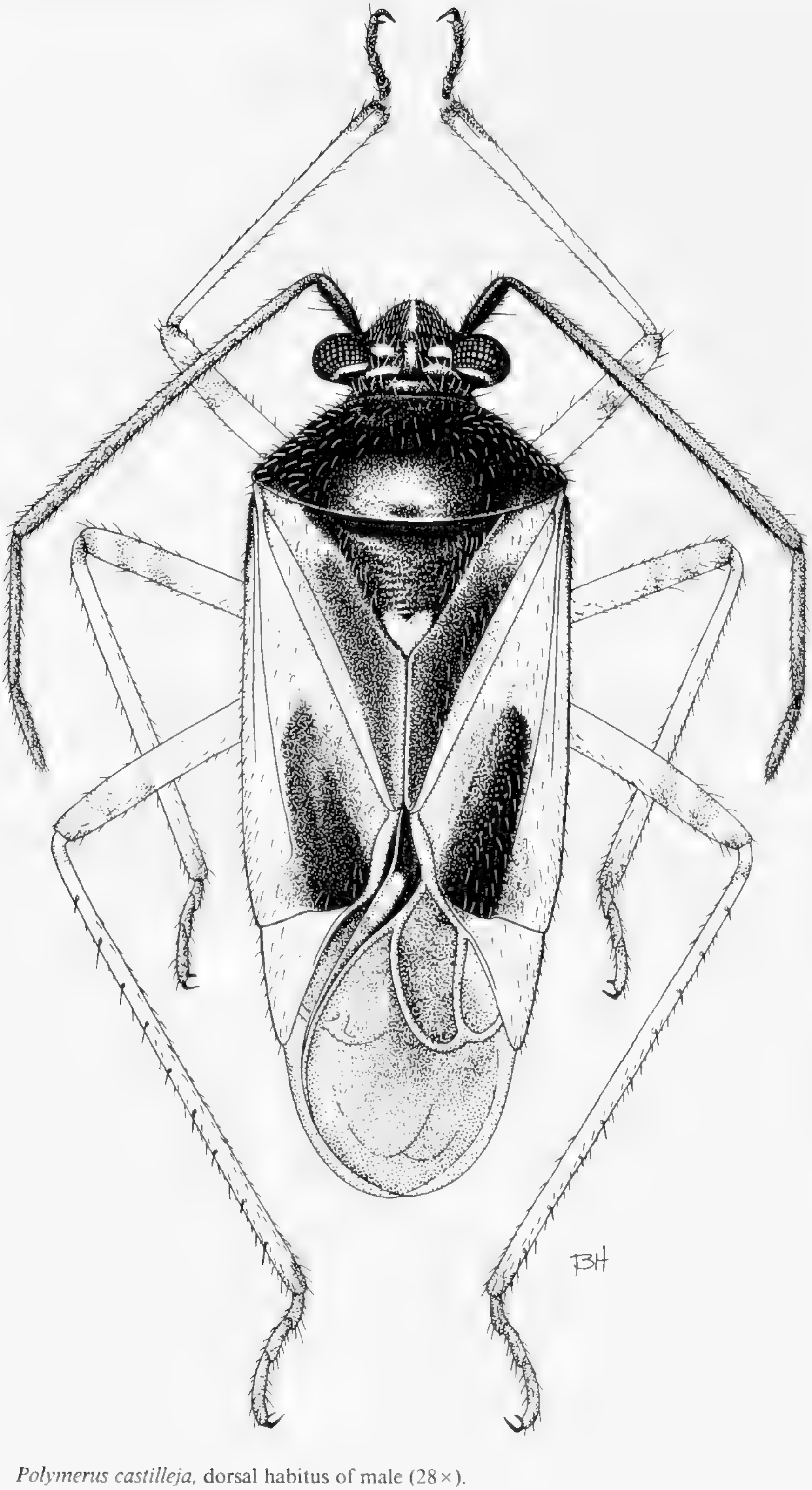
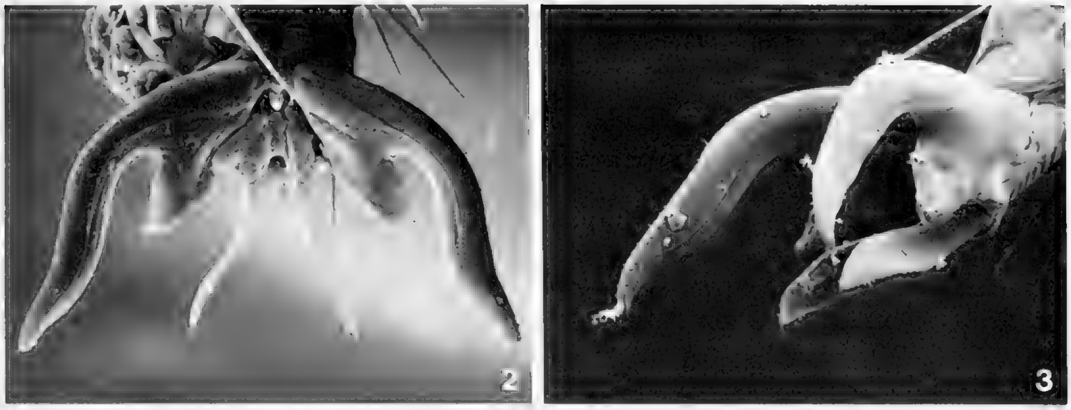


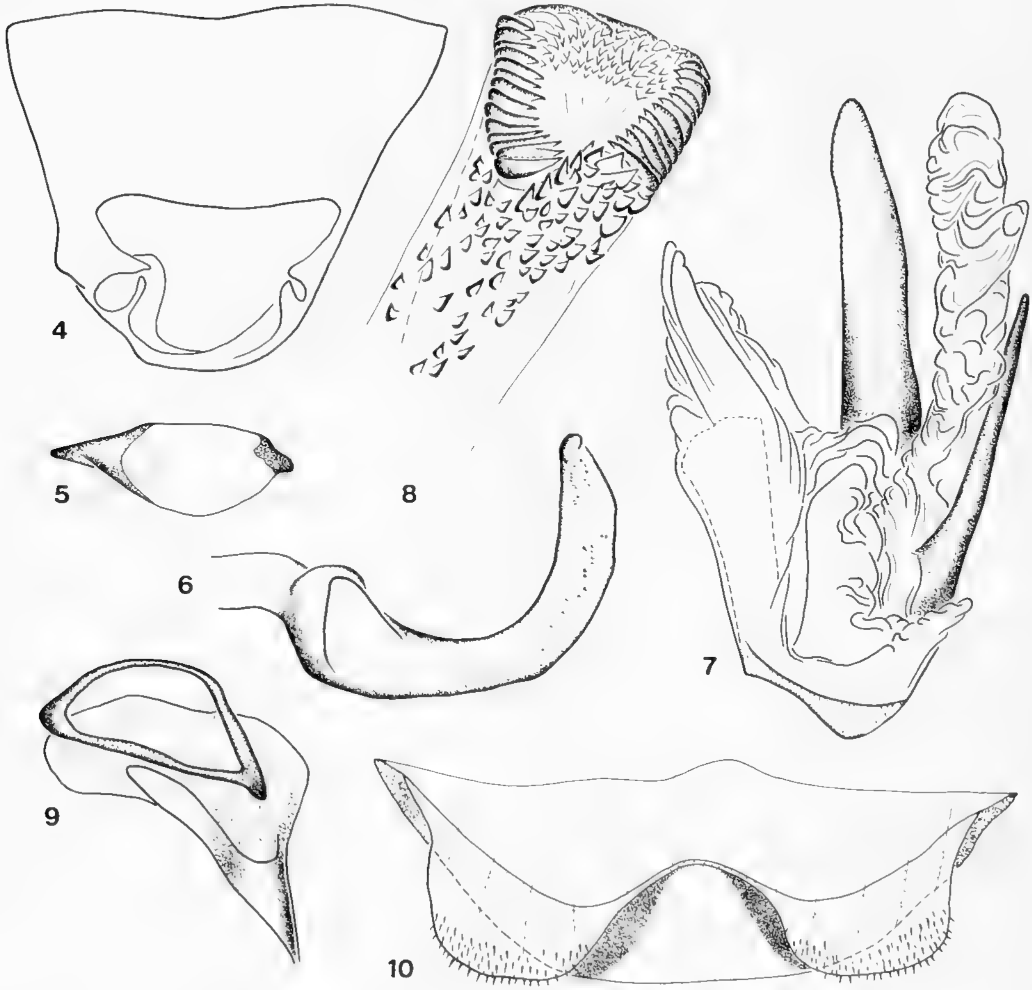
Fig. 1. *Polymerus castilleja*, dorsal habitus of male (28×).



Figs. 2, 3. *Polymerus castilleja.* Pretarsal structures (49×). 2, End on view. 3, Lateral view.

emarginate anteriorly, ventral margin extending ventrad of fossa in lateral view; antenna beset with fine, fuscous to black, suberect, simple setae, length of segment I 0.35–0.41, II 1.70–2.05; length of labium 2.30–2.63, reaching fourth to sixth abdominal sternite. **Pronotum.** Trapeziform in dorsal view; posterior width 1.40–1.64; posterior margin broadly curved, lateral margin rounded; callus smooth and weakly produced. **Hemelytra.** Macropterous, subparallel sided, sometimes tapered posteriorly in dorsal view. **Legs.** Tibiae longer than femora; color variable—light specimens with coxae, trochanters, and femora on basal half and apically testaceous, femora with diffuse stripes, tibiae, and first and second tarsal segments orange red, third segment and claws black;—dark specimens with coxae and femora with diffuse spots or stripes and apically, tibiae narrowly apically and basally, and tarsi dark fuscous to black; claws broad, strongly produced basally (Figs. 2, 3). **Ventral aspect.** Color variable ranging from black ground color with proepisternum, propleura, and sternum entirely, epimeron bordering coxae, and posterior edge of evaporative area of peritreme testaceous, and with band ventrad of abdominal spiracles red fuscous—to testaceous ground color with proepeisternum basally, propleura medially, sternum mesially, abdominal sternites laterally and mesially dark fuscous or black. **Genitalia.** *Genital capsule:* With broad, truncate, and apically spinose tubercle dorsolaterad of left paramere insertion (Fig. 4). *Left paramere:* Broadly 'U' shaped, surface without tubercles or spines; shaft extending beyond sensory lobe in lateral view; sensory lobe small, flattened on lateral surface; arm longer than shaft; shaft slightly compressed, broader than cylindrical arm, tapering to rounded apex (Fig. 6). *Right paramere:* Small, ovoid, with only apex and base entirely sclerotized, median portion hyaline; apex with small tubercle (Fig. 5). *Vesica:* Ductus seminis: Cylindrical, gradually expanded toward gonopore. Secondary gonopore: aperture with diffuse spinulae, incomplete, left side with deep fissure (Fig. 8). Membrane: Basal sclerite encircling base of membrane, projecting posteriad of ductus, and extending distally to form a thinly sclerotized lobe of the membrane; two lobal sclerites, one short and needlelike, one much longer, broader and clawlike (Fig. 7); portion of membrane adjacent to gonopore with surficial spiculae which merge with aperture of gonopore (Fig. 8).

Female.—Macropterous. Vestiture similar to, coloration usually lighter than (with dark markings much less extensive), and bodyform more robust than, male. **Measurements.** Total length 4.70–5.80, length



Figs. 4–10. *Polymerus castilleja.* Genitalic structures. 4–8, Male genitalia. 4, Genital capsule, dorsal view (55×). 5, 6, Parameres, lateral view (110×). 5, Right. 6, Left. 7, 8, Vesica. 7, Frontal view (110×). 8, Detail of secondary gonopore, frontal view (220×). 9, 10, Female genitalia (110×). 9, Right sclerotized ring, anterior view. 10, Posterior wall, posterior view.

from apex of tylus to cuneal fracture 3.55–4.40; width across eyes 0.98–1.15, interocular width 0.45–0.54; anteocular length 0.31–0.43; length of antennal segment I 0.35–0.40, II 1.60–2.08; length of labium 2.40–2.88, reaching fourth to sixth sternite; posterior width of pronotum 1.60–2.03. **Genitalia.** *Sclerotized rings:* Separate, subtriangular, moderate size. Dorsal labiate plate: Small, adhering and following curvature of ramae anteriad, attaining lateral margins of rings in dorsal view. Ventral labiate plate: Not spanning rings, subquadrate, slightly shorter than rings in dorsal view (Fig. 9). *Posterior wall:* Inter-ramal sclerite: Narrow, elongated laterally, sometimes disarticulated medially. Median process and dorsal structure: Obsolete. Inter-ramal lobes: Large, crescent shaped, extending ventrad to even with ventralmost portion of dorsal labiate plate in posterior view; surface structure with needlelike spiculae (Fig. 10).

Etymology.—Named after the genus of the host plant.

Holotype ♂.—UNITED STATES. **Oregon.** *Linn Co.,* H. J. Andrews Experimental Forest, 1 mi N of Frissel Pt., July 28, 1981, coll. G. M. Stonedahl, ex *Castilleja* sp.; deposited at AMNH.

Paratypes.—UNITED STATES. **California:** *Alpine Co.,* Ebbetts Pass, Aug. 6, 1974, F. G. Andrews, K. S. Corwin 1♀ (CAFA). *Modoc Co.:* 3 mi S of Bug Station, Hwy. 139, June 20, 1956, J. Schuh, sweeping *Castilleja* sp. 13 ♂, 9 ♀ (OSU); Fandago Pass Summit, July 3, 1979, 1890 m, R. T. Schuh & B. M. Massie, ex *Castilleja* sp. 9 ♂, 13 ♀ (AMNH). *Shasta Co.:* 1 mi S of Jct. of Rts. 89 & 299, 1219 m, July 9, 1980, R. T. Schuh & G. M. Stonedahl, ex *Castilleja applegatei* Fern. var. *fragilis* (Zeile) N. Holmgren 11 ♂, 32 ♀ (AMNH, CAS); "same locality and host," G. Stonedahl 11 ♂, 7 ♀ (AMNH). *Sierra Co.,* Sierraville, June 28, 1966, C. E. Hawkins 1 ♂, 1 ♀ (OSU). *Siskiyou Co.,* 2.5 mi N of Medicine Lk. on Medicine Lake Rd., July 18, 1985, G. M. Stonedahl & J. D. McIver, ex *Castilleja* sp. 5 ♂, 3 ♀ (AMNH). **Oregon:** *Jackson Co.,* Siskiyou Summit on I-5, July 4, 1982, T. J. Henry & G. M. Stonedahl, ex *Castilleja* sp. 4 ♂, 2 ♀ (AMNH); "same label data," 4300 ft. 6 ♀ (USNM). *Klamath Co.,* Bly Mt., June 14, 1958, J. Schuh 1 ♂ (OSU). *Lake Co.:* Summer Lake: June 16, 1938, Grey & Schuh 1 ♂, 1 ♀ (AMNH); Aug. 16, 1939 1 ♀ (AMNH); "same date," Schuh & Scott 1 ♀ (AMNH). Warner Cyn. nr. Lakeview roadside, 2 mi E of Hwy. 395, 5450 ft., July 19, 1971, Lattin 1 ♀ (OSU). *Linn Co.:* "with same label data as holotype," 9 ♂, 3 ♀ (AMNH, OSU); Monument Peak, 8 mi ESE of Gates Summit, 4725 ft., June 16, 1960, J. D. Lattin 1 ♂ (OSU).

Additional specimens.—**California:** *San Luis Obispo Co.,* Arroyo Grande Creek, SW

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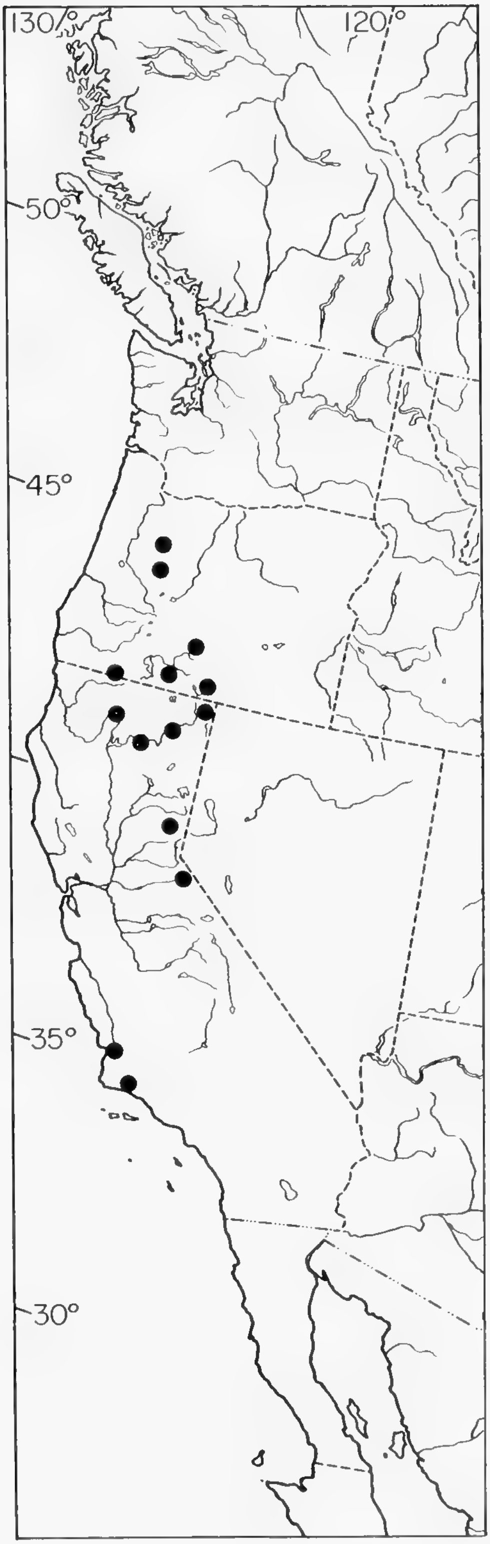

Fig. 11. Distribution of *Polymerus castilleja.*

of San Luis Obispo, ±160 m., May 18, 1985, R. T. Schuh & B. M. Massie, ex grasses and forbs 1 ♀ (AMNH). *Santa Barbara Co.,* Upper Oso Cmpgrd., off Rt. 154, 310 m., May 7, 1985, R. T. Schuh & B. M. Massie 1 ♀ (AMNH). These two specimens were excluded from the paratype series because they were not associated with male specimens, and were collected at localities removed far to the southwest of the paratypic localities.

Hosts.—All specimens where collected on either *Castilleja* sp. or *C. applegatei* Fern. var. *fragilis* (Zeile) N. Holmgren (Scrophulariaceae). Hitchcock and Cronquist (1973) summarized the distribution of *applegatei* var. *fragilis* as occurring in sagebrush (*Artemisia* spp.) and open coniferous wooded slopes in central Idaho, across eastern Oregon to the southern Cascades and south to northern Nevada and eastern California.

Distribution.—The Cascade region of westcentral Oregon south to the Sierra region of northern California. The true range of *castilleja* may be more extensive because, as noted above, the range of at least one of its host plants is more widespread than presently known for the plant bug (Fig. 11).

Discussion.—There are no keys to the *Polymerus* species which occur within the distributional range of *castilleja. Polymerus castilleja* keys to *hirtus* Knight in Kelton (1980), and *basalis* (Reuter) in Knight (1941). However, *castilleja* is easily separated from these and all other *Polymerus* species by the enlarged clawbase. Additionally, the labium of *castilleja* is longer (2.30–2.88) than either *hirtus* (1.75–1.89) or *basalis* (less than 2.30), and it is questionable whether *basalis* or *hirtus* actually occur within the range of *castilleja.*

*Polymerus basivittis* (Reuter) was collected along with *castilleja* on Indian paintbrush at the H. J. Andrews Experimental Forest, Linn County, Oregon and Fandango Pass, Modoc County, California. These two species are distinguished by the length of the labium and body conformation in addition to the different claw structure. The labium of *basivittis* barely reaches the metacoxae, whereas the labium of *castilleja* reaches from the fourth to the sixth abdominal sternite. Both sexes of *basivittis* are compact, ovoid bugs, while the sexes of *castilleja* are dimorphic with the males elongate. Kelton (1980) reported that *basivittis* has been collected on the widespread *Galium boreale* L. (Rubiaceae).

Superficially the female of *castilleja* has the appearance of *robustus* Knight. However, the latter species is distributed in southern California and possesses a labium which barely reaches the metacoxae.

Schwartz (1987) included a preliminary analysis of the genitalic attributes of many representative mirine genera (234 species encompassing 110 genera, including all the North American genera). In light of that study and from character information gleaned from several species of *Polymerus* dissected for the present paper, I will enumerate what I believe are autapomorphic genitalic characters for the genus. I examined the genitalia of both sexes of the following species: *basivittis, basalis* (Slater 1950: pl. 3, fig. 5), *diffusus* (Uhler), *nigritus* (Fallén), and *testaceipes* (Stål). The male genitalia of three additional species were examined only through published illustrations: *atacamensis* Carvalho and Carpintero (Carvalho and Carpintero 1986, figs. 11, 13), *chrysopsis* Knight (Kelton 1959, fig. 32), and *peruanus* Carvalho and Meléndez (Carvalho and Meléndez 1986, fig. 6).

*Polymerus* seems to be diagnosed by these characters:

(1) The right paramere is relatively small for a mirine, and only sclerotized at the apex and base, with the remainder of the paramere hyaline (Fig. 5). This construction was also noted by Kelton (1959) and illustrated by Wagner (1973: fig. 324 b, e, h, l, o) for *asperulae* (Fieber), *brevicornis* (Reuter), *microphthalmus* (Wagner), *palustris* (Reuter) and *unifasciatus* (Fabricius).

(2) The secondary gonopore is modified from the simple coil-like, uninterrupted, ap-

erture of many mirine genera to a deeply notched aperture with strong concentric rings of minute spinulae (Fig. 8). The spinulae of the gonopore are intermixed with the spinulae of the adjacent portion of the vesical membrane.

(3) The dorsal structure and median process of the posterior wall are usually obsolete and flattened in the plane of the interramal sclerite, respectively (Fig. 10).

These genitalic features further define *Polymerus,* which is otherwise inadequately diagnosed as medium sized, finely punctate member of the Mirini, with densely distributed vestiture of shining light to golden sericeous simple setae. The hypothesis of the genitalic autapomorphies of *Polymerus* is tentative, as an understanding of the distribution of the features listed above within the tribe is limited.

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I thank the following individuals for providing material from collections in their care: A. Asquith and J. D. Lattin, Systematic Entomology Laboratory, Oregon State University, Corvallis (OSU); T. J. Henry, Systematic Entomology Laboratory, USDA, % National Museum of Natural History, Washington, D.C. (USNM); and R. T. Schuh, American Museum of Natural History, New York (AMNH). I thank B. Hall, Corvallis, Oregon, for the fine illustration of the adult male of *castilleja* and J. D. Lattin, through funds provided by NSF BSR-8514325, for providing the financial support for it. I thank T. J. Henry, J. D. Lattin, R. T. Schuh and an anonymous reviewer for reading and commenting on the manuscript. Financial support for field work and technical assistance was received from NSF Grants DEB 81-13401 and BSR 86-06621 to R. T. Schuh, AMNH.

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91(3), 1989, pp. 468–472

# LARVAL-SEX AND HOST-SPECIES EFFECTS ON LOCATION OF ATTACHMENT SITES OF LAST-INSTAR BAGWORMS, *THYRIDOPTERYX EPHEMERAEFORMIS* (LEPIDOPTERA: PSYCHIDAE)

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*Abstract.*—In last-instar bagworms, *Thyridopteryx ephemeraeformis,* on the deciduous tree *Robinia pseudoacacia,* males more frequently attached their cases to leaves, and females more frequently attached their cases to branches. Both males and females more frequently attached their cases to branches, rather than leaves, of the evergreen *Pinus strobus.* Diameters of branches that bagworms used as case-attachment substrates were significantly related to bagworm sex and host species. Possible adaptive significances of these phenomena are discussed.

*Key Words:* Psychidae, *Thyridopteryx ephemeraeformis,* caterpillar behavior, *Juniperus virginiana, Pinus strobus, Robinia pseudoacacia*

The bagworm, *Thyridopteryx ephemeraeformis* (Haworth), is a polyphagous herbivore which usually feeds on woody plants. It occurs from the West Indies north to Vermont, Michigan, and Minnesota and west to Kansas and Texas, being most common in southeastern United States according to Davis (1964) and Longfellow (1980). Many other workers including Riley (1869), Haseman (1912), Jones (1927), Jones and Parks (1928), Barrows (1974), Barrows and Gordh (1974), Kaufmann (1968), Kulman (1965), Leonhardt et al. (1983), and Neal (1986) have increased our knowledge of bagworm biology. As background for our study, we present a brief generalized summary of bagworm biology in the United States based on these previous investigations.

In August to October, depending on locality, an inseminated female lays all of her eggs in her pupal exuviae which remain in the case that she made as a larva. Her egg-laden case hangs on her host plant over the winter, and her eggs hatch in late April to early June. First-instar larvae emerge from cases, construct conical cases of silk and plant materials around themselves, and may balloon, each by a silken thread, to a new location. Many no doubt die due to predation, landing on unsuitable hosts, and other factors. A larva that finds a suitable host passes through five to eight instars (Longfellow 1980), enlarging its case as it grows, before it pupates in late summer to early fall. Before pupation, a larva fastens the anterior end of its case to a substrate (usually a food plant), and turns 180 degrees assuming a head-down position. Pupae transform into adults in 2 to 3 weeks. Males are typical of most kinds of adult Lepidoptera in having wings, legs, compound eyes, antennae, and other adult characters. Females are essentially "egg bags" having reduced compound eyes, vestigial mouthparts and legs, and no wings or antennae. After insemination, a female lays her eggs in her pupal exuviae, and then either dies in her larval case or leaves it before dying. Most bagworms, which are not killed by *Homo sapiens* L., are killed by insect and other parasites and invertebrate and vertebrate predators before they reproduce.

Our study tests five hypotheses about case-attachment behavior of bagworm last-instar larvae on three hosts: the evergreen conifers redcedar, *Juniperus virginiana* L., and white pine, *Pinus strobus* L., and the deciduous tree black locust, *Robinia pseudoacacia* Ehrh. These hypotheses were prompted by features of bagworm biology, its host-plant architectures, and our preliminary field observations regarding case-attachment sites (Barrows 1974 and later observations). Our hypotheses are: (1) Female bagworms use branches rather than petioles as case-attachment sites on *R. pseudoacacia* (experiment 1). (2) Males use branches rather than petioles as case-attachment sites on *R. pseudoacacia* (experiment 2). (3) Females use branches rather than leaves as case-attachment sites on *P. strobus* (experiment 3). (4) Males use branches rather than leaves as case-attachment sites on *P. strobus* (experiment 4). (5) Bagworm case-attachment-site diameter on *R. pseudoacacia, P. strobus,* and *J. virginiana* is related to bagworm sex and host species (experiment 5).

The bagworm's range broadly overlaps those of all three of its host plants that we studied (Fernald 1950), and it can be locally common on these species. *Robinia pseudoacacia* has alternate, petiolate compound leaves from 20 to 36 cm long. *Pinus strobus* usually has leaves in fascicles of five, each 7 to 12 cm long and persistent on a branch for about 2 yr (Otis 1926, Ewers and Schmid 1981). *Juniperus virginiana* has small sessile (petioleless), 1.5–12-mm long leaves which persist on plants for 5 to 6 yr (Otis 1926). Bagworms attach their last-instar cases to branches, not individual leaves of *J. virginiana.*

## MATERIALS AND METHODS

Bagworms were sampled in Prince William, Fairfax, and Arlington Counties in northern Virginia in September to October 1983 and 1984 before autumn leaf fall. We measured attachment sites of bagworms, that were up to 2.3 m above the ground and on their hosts, from 25 trees of *R. pseudoacacia,* 10 trees of *P. strobus,* and 15 trees *J. virginiana.* Bagworms occurred on other parts of these trees which we did not sample. The greatest diameters of pupal-case attachment sites, which were nearly round to elliptical in cross section, were measured using Manostat® dial calipers accurate to 0.05 mm. We used data only from cases whose former occupants could be sexed with certainty. A male's case had his pupal exuviae protruding from its distal opening or was intact and empty with a distal tube with a circular cross section through which he obviously emerged. A female's case contained eggs in her pupal exuviae.

To test hypotheses 1–3, we used binomial tests (BTs) to look for possible differences between observed and expected attachment-site frequencies. We designated expected frequencies as 50% on branches and 50% on leaves because each bagworm had a hypothetical 50% chance of using one or the other substrate by chance alone. We tested hypothesis 5 by examining the 95% confidence intervals of the differences between all possible pairs of means. This method is more straightforward, gives more information (the magnitudes of differences between means and their 95% confidence intervals), and makes each pairwise comparison at an alpha level of 0.05. Commonly used simultaneous test procedures, e.g. the Duncan's multiple-range test, do not have these advantages (Jones 1984). The SAS computer package (SAS® Institute 1985) was used to perform statistical analyses.

## RESULTS AND DISCUSSION

Experiment 1.—In 1983, 88 of the 92 females collected from *R. pseudoacacia* were

Table 1. Experiment 5. Mean diameters of attachment sites of cases of six bagworm categories, their 95% confidence intervals, ranges, and sample sizes (N).

| | Mean (mm) | 95% CI (mm) | Range (mm) | N |
|---|---|---|---|---|
| Males on: | | | | |
| *Robinia pseudoacacia* | 1.46 | 0.08 | 0.75–4.50 | 122 |
| *Juniperus virginiana* | 1.70 | 0.10 | 0.95–3.60 | 86 |
| *Pinus strobus* | 2.09 | 0.14 | 0.90–4.00 | 69 |
| Females on: | | | | |
| *Juniperus virginiana* | 2.42 | 0.06 | 1.20–4.90 | 328 |
| *Pinus strobus* | 2.84 | 0.10 | 1.70–5.50 | 171 |
| *Robinia pseudoacacia* | 2.93 | 0.10 | 1.65–9.05 | 303 |

on branches; four were on petioles. In 1984, 297 of the 303 females collected from *R. pseudoacacia* were on branches; 4 were on petioles. Thus, female bagworms more frequently attached their cases to branches (both years, $P < 0.0001$, BT). Luther P. Brown (personal communication), who sampled bagworms in Maryland, did not find any female cases on petioles of *R. pseudoacacia,* but he sampled in November after a substantial leaf drop could have occurred. It may be reproductively advantageous for a female last instar to attach her case to a branch, rather than to a deciduous leaf which would fall to the ground. First, this site would keep her eggs above the ground where they might have a lower probability of mammalian predation and fungus infection (Barrows 1974, Berisford and Tsao 1975, Munte 1982). Second, her choosing this site would put her first-instar offspring in a place where they can readily find food and from where they can balloon to other host plants.

Experiment 2.—In 1983, of 36 males collected from *R. pseudoacacia,* 33 were on petioles and 3 were on branches. In 1984, of 122 males, 89 were on petioles and 33 were on branches. Thus, males preferentially attached to petioles (1983, $P = 0.0003$, BT; 1984, $P < 0.0001$, BT). When we originally made our second hypothesis, we knew of no reason why males should preferentially attach to petioles rather than branches of this plant. Because males leave no eggs in their cases, it should be of no consequence to their fitnesses (measured as number of offspring) if their empty pupal cases fall to the ground with deciduous plant leaves. However, possible advantages of pupal-case attachment to petioles to male last-instars and emerging males are worthy of investigation.

Experiments 3 and 4.—In 1984, all 171 females and 86 of 89 males collected from *P. strobus* were attached to branches rather than leaves or leaf clusters. Thus, both sexes preferentially attached to branches (both sexes, $P < 0.0001$, BT). When we made our third and fourth hypotheses, we assumed that bagworms, attached to leaves or a group of leaves, would usually overwinter on their hosts because they were likely to attach to at least some leaves that would not soon dehisce. Under this hypothesis, case-attachment location on *P. strobus* should have little effect on bagworm fitnesses, but according to our results, bagworms preferred branches. Possible mechanistic explanations for this behavior include bagworms tend to attach their pupal cases to firm rod-shaped substrates rather than to more flexible single leaves or clusters of leaves, and they are repelled by stimuli from leafy areas just before attaching their pupal cases.

Experiment 5.—Data regarding bagworm sex, host, attachment-site diameters, and sample sizes are summarized in Table 1,

Table 2. Experiment 5. All pairwise comparisons of six bagworm categories indicating the differences between means and 95% confidence intervals of these differences for each pair.

| | MRS[a] | MJV | MPS | FRS | FJV |
|---|---|---|---|---|---|
| MJV | 0.24 ± 0.13 | | | | |
| MPS | 0.63 ± 0.15 | 0.39 ± 0.16 | | | |
| FRS | 1.47 ± 0.12 | 1.23 ± 0.33 | 0.84 ± 0.16 | | |
| FJV | 0.96 ± 0.10 | 0.72 ± 0.12 | 0.33 ± 0.14 | 0.51 ± 0.11 | |
| FPS | 1.38 ± 0.12 | 1.14 ± 0.14 | 0.75 ± 0.16 | 0.09 ± 0.13 | 0.42 ± 0.11 |

[a] MRS = males on *Robinia pseudoacacia*; MJV = males on *Juniperus virginiana*; MPS = males on *Pinus strobus*; FRS = females on *R. pseudoacacia*; FJV = females on *J. virginiana*; FPS = females on *P. strobus*. Members of all pairs are different from one another at an alpha level of 0.05 except for FRS and FPS because the 95% confidence interval of this pair's difference between means contains 0.

and pairwise comparisons of differences between means are listed in Table 2. On all three hosts, females attached their pupal cases to significantly larger-diameter branches than did males. Bagworms sampled by L. P. Brown (personal communication) behaved similarly to the ones we sampled on *R. pseudoacacia* and *J. virginiana*. This may be due to the facts that females are larger than males, and larger bagworms use larger-diameter attachment sites than do smaller ones (Brown, personal communication); and on *R. pseudoacacia*, males used petioles while females used branches. Males used a significantly different mean attachment-site diameter among all hosts, and females used a significantly different mean attachment-site diameter except between *R. pseudoacacia* and *P. strobus* (Table 2).

In conclusion, our study suggests some other directions for future investigation including: (1) behavior mechanisms that affect bagworm choice of diameters and kinds of case-attachment sites; (2) possible effects of bagworm genetics, parasites, and site availability, on this behavior; and (3) the possible relationship between male attachment-site location on *R. pseudoacacia* and parasitism in subsequent bagworm generations. Parasitized cases on leaves fall to the ground, and this possibly eliminates some parasites from bagworm populations.

## ACKNOWLEDGMENTS

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# REDESCRIPTION OF *CULEX* (*MELANOCONION*) *DELPONTEI* DURET, 1968 AND *CX.* (*MEL.*) *PEREYRAI* DURET, 1967, FROM SOUTHERN BRAZIL

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*Abstract.*—Adults of both sexes of *Culex* (*Melanoconion*) *delpontei* Duret and *Cx.* (*Mel.*) *pereyrai* Duret, are redescribed and illustrated. Diagnostic characters for separating these from similar species of the Spissipes Section of subgenus *Melanoconion* are given. Distribution and epidemiological aspects are considered.

*Key Words:* Insecta, Diptera, Culicidae, *Culex, Melanoconion,* Brazil

Recent publication of arbovirus investigation in Argentina (Mitchell et al. 1985, 1987a), report the isolation of several viral strains from *Culex* (*Melanoconion*), many obtained from *Cx. delpontei* Duret. Various strains were isolated including several belonging to the Venezuelan equine encephalitis virus (VEE) complex. *Culex delpontei* is now considered as important arbovirus vector, but much about this species remains unknown, including characters for identification.

During studies on the mosquitoes of the Ribeira Valley and other regions of São Paulo State, Brazil, several adults of *Cx. delpontei* and *Cx. pereyrai* Duret, were collected. We take this opportunity to redescribe them with the objective of achieving a better characterization for purposes of identification. Ideally types should be examined, but, as far as is known, they were retained in the collection of the author of species and so of no easy access. By other side, descriptions of these species are well enough illustrated to leave no doubts about their identities.

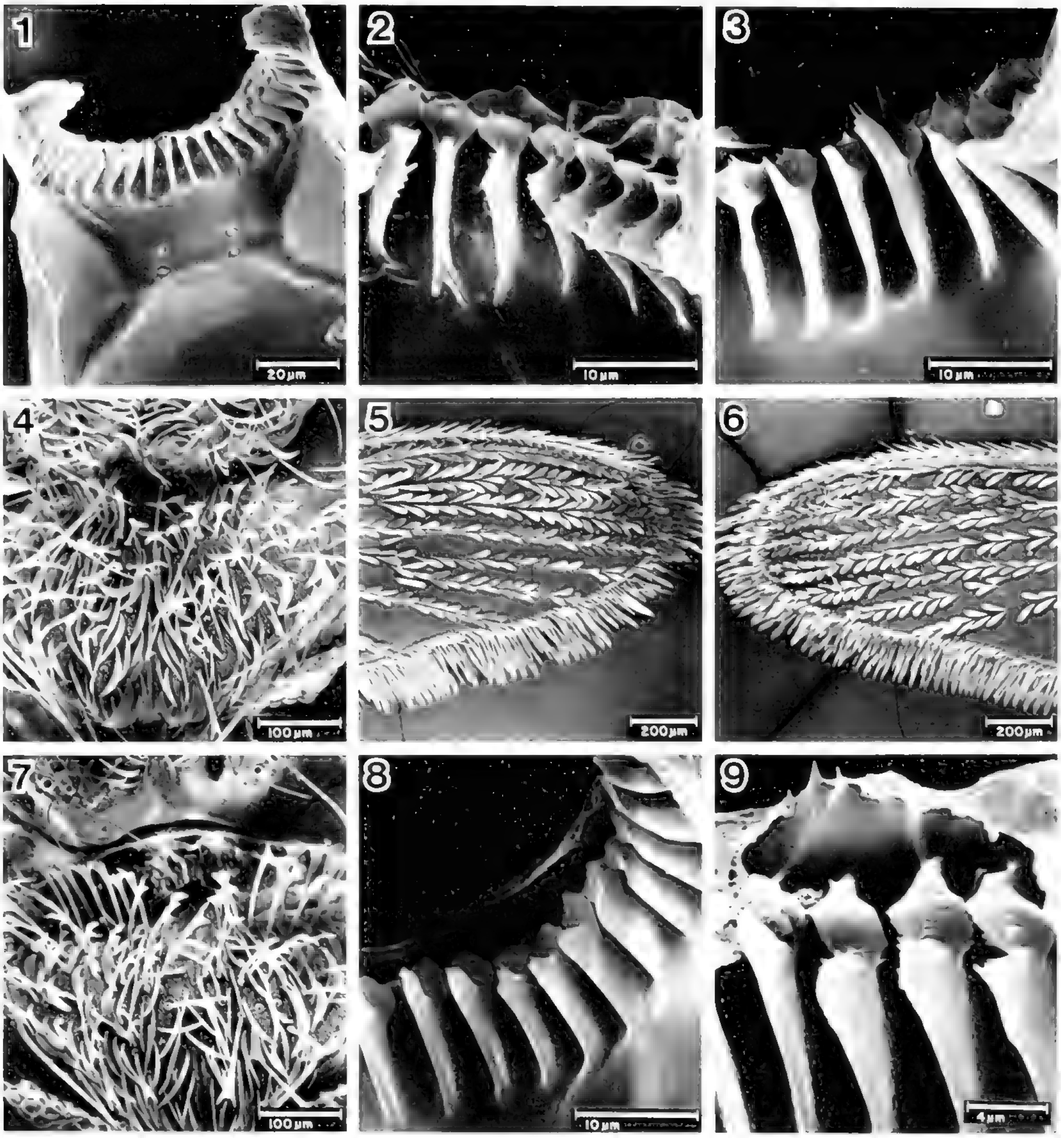
The terminology of Harbach and Knight (1980) was utilized for the descriptions, except for the wing veins which follow Belkin (1962).

### *Culex* (*Melanoconion*) *delpontei* Duret
Figs. 1–6, 10, 11 and 13

*Culex* (*Melanoconion*) *paracrybda* of Duret 1953: 119.

*Culex* (*Melanoconion*) *delpontei* Duret 1968: 8 (type not seen; type locality Argentina, Chaco, Las Palmas; holotype deposited in the collection of the author of specie (Knight and Stone 1977)). Sirivanakarn and Jakob 1981: 199.

Female.—*Head:* Antenna dark, length about 2.00 mm; flagellum normal, whorls normally with 6 setae. Proboscis entirely dark-scaled; length 1.66–1.88 mm, mean 1.72 mm. Maxillary palpus entirely dark-scaled; length 0.28–0.33 mm, mean 0.30 mm, about 0.17 of the proboscis length. Vertex (Fig. 4) with narrow falcate scales in a small median dark patch, between pale whitish ones, broad appressed dingy white in small lateral patch; forked scales dark. Occipital region with some pale whitish falcate scales. *Cibarial armature* (Figs. 1, 2, 3



Figs. 1–9. Adult structures. *Culex delpontei* 1, female cibarial armature. 2,3, cibarial teeth. 4, vertex and occipital region. 5, dorsal view of right wing. 6, ventral view of right wing. *Culex pereyrai.* 7, vertex and occipital region. 8, cibarial teeth. 9, cibarial teeth showing thorn-shaped processes on the posterior border of the cibarial bar.

and 10). Cibarial bar developed, moderately chitinized, strongly concave, with about 22 small cibarial teeth arranged in single row, with sizes gradually smaller laterally where they may be visible in lateral profile; many irregular chitinized folds on posterior border of cibarial bar where folds sometimes end as minute prickle; cibarial teeth laminar shaped with two recognized parts, anterior and posterior; the first one, including nearly third or fourth total tooth dorsal length, as a thin sagital plate; second one as transversal plate, lozange or hexagonally roughly outlined; minute irregularly disposed prickles may be seen at the margins of both parts. Cibarial dome nearly circular, concave cap covered by superficial denticles. *Thorax:* Scutal integument brown or dark brown, except yellow paratergite; scutum almost entirely covered by uniform fine falcate dark bronzy scales, with some colorless ones on prescutellar area; scutal setae conspicuous (acrostichal setae absent), brownish black with reddish sheen; antealar setae, shiny yellow to golden. Scutellar scales as scutal scales; lateral lobe each with 3–5 large setae, median lobe with 5,6 large setae. Antepronotum dark, without scales, with scattered dark and golden setae. Postpronotum brown dorsally and yellow ventrally, with narrow dark scales, like scutal scales, posterodorsal margin with 3–5 upper dark and lower golden setae. Pleural integument pale yellow; with shiny golden yellow setae; pleural setae: about 9–11 upper proepisternal, 4–7 prealar, 5–8 upper mesokatepisternal, 8–10 lower mesokatepisternal, 5–7 upper mesepimeral and 1 lower mesepimeral. Pleura with scales on mesokatepisternum: a small patch of pale spatulate scales on lower posterior border and sometimes with 2,3 colorless spatulate scales on upper corner. *Wing* (Figs. 5, 6): Length 2.77–3.04 mm, mean 2.87 mm; mostly dark-scaled, with a minute patch of clear scales on base of costa; cell $R_2$ 3.48–5.17 of vein $R_{2+3}$, mean 4.37; cell $M_2$ 0.71–0.75 of cell $R_2$; subcosta intersects costa before furcation of $R_{2+3}$. Dorsal scaling: appressed spatulate scales on costa, subcosta, R, $R_1$, $R_{4+5}$, distal 0.5 of $M_{1+2}$, $M_{3+4}$, Cu, $Cu_1$, $Cu_2$ and basal 0.5 of 1A; linear plume scales on $R_s$, $R_{2+3}$ and M; inclined narrow spatulate scales on $R_2$, $R_3$, proximal 0.5 of $M_{1+2}$ and distal 0.5 of 1A; remigium with appressed spatulate scales and long golden setae distally. Ventral scaling: appressed spatulate scales on costa, subcosta, $R_s$, $R_{2+3}$, base of $R_2$, base of $R_3$ and on M; linear plume scales covering nearly basal 0.5 of $R_1$, on basal 0.3 of $Cu_1$, $Cu_2$ and middle of 1A; inclined narrow spatulate scales on distal 0.5 of $R_1$, $R_2$, $R_3$, $R_{4+5}$, $M_{1+2}$, $M_{3+4}$, distal 0.7 of $Cu_1$ and distal 0.6 of 1A; Cu and basal 0.4 of 1A devoid of scales. *Halter:* Yellow, capitellum slightly darker at apex. *Legs:* Anterior surface of forecoxa pale-scaled; anterior surface of midcoxa with longitudinal patch of pale scales; anterior surface of hindcoxa devoid of scales. Antero- and posteroventral surfaces of foretrochanter pale-scaled; midtrochanter with antero- and posteroventral surfaces pale-scaled; antero- and posteroventral surfaces of hindtrochanter pale-scaled. Fore- and midfemora mainly pale-scaled, posterior surface of forefemur with indistinct longitudinal stripe of dingy pale scales, posteroventral surface of midfemur with dingy pale scales, hindfemur with complete dorsal stripe of dark scales distally widening and expanding onto anterior and posterior surfaces at apex. Tibiae and tarsi entirely dark-scaled. *Abdomen:* Tergum I with median posterior patch of dark scales; terga II–VII dark-scaled with basolateral patches of white scales; tergum VIII mainly dark-scaled, with small basolateral patch of white scales. Sterna II–IV white-scaled; sterna V,VI mainly white-scaled, occasionally with mixed dark scales distally; sternum VII infrequently entirely white-scaled, generally with dark scales distally; sternum VIII with lateral patches of white scales. *Genitalia* (Fig. 10): Tergum IX narrowed in middle, lobes each bearing 6–11 setae. Upper vaginal lip narrow, distinct; lower vaginal lip and insula indistinct; about 7,8 insular setae in cluster. Upper vaginal sclerite distinct, inverted U-shaped, chitinized. Postgenital lobe short, distally rounded, with 7–13 setae on either side of midline, setae mostly on ventral surface.

Male.—Like female except for sexual differences as follow. *Head:* Antenna strongly plumose, length about 1.78 mm. Proboscis entirely dark. Maxillary palpus dark, length about 2.52 mm, extending beyond tip of proboscis by about apical 0.5 of palpomere 4 and all of palpomere 5; palpomeres 4 and 5 entirely covered by dark strong setae; palpomere 3 with 8,9 setae at apex. *Abdomen:* Tergum II entirely dark-scaled; tergum III with small basolateral white patch; terga IV–VII with basolateral white patches; tergum VIII (ventral in position) mostly white-scaled, with deep V-shaped median posterior emargination and several long bristles mixed with shorter setae (Fig. 11); sterna predominantly white-scaled, with small number of dark scales distally on sterna V–VII; sternum VIII (dorsal in position) with basolateral white patches. *Genitalia* (Fig. 11): Ninth tergal lobe small, columnar shaped, widely separate, bearing long and slender setae on 0.5 of distal surface. Gonocoxite stocky, outer margin convex, inner moderately concave; ventrolateral surface with strongly developed setae and small number of scales, mesal surface with small setae in indistinct rows extending from base to level of subapical lobe, lateral surface with sparse patch of slender setae (lsp) from proximal area to level of subapical lobe, proximal part of ventrolateral surface with scales; subapical lobe distinctly divided, divisions approximated; proximal division not divided, lengthened, with an apical infundibular and hyaline expansion partially covering insertions of setae *a* and *b* which are long, enlarged and sinuous with another hyaline, broad and hooked-falciform seta beyond middle and 5–11 long, slender and curved setae from base to level of insertion of hooked-falciform seta; distal division with 2 approximated uneven arms, each bearing an apical setae, proximal arm stronger, distally enlarged, bearing 1 long hooked seta *h*2 saberlike setae(s) (one larger than the other) inserted on prominent tubercle near middle of arm, distal arm slender, cylindric, bearing 1 stiff short nearly saberlike seta (s) and 4 foliform setae (f) (2 similar and 2 slightly larger and dissimilar in size). Gonostylus slender, curved, moderately narrowed distally, crest slightly wrinkled on ventral surface before apical snout; gonostylar claw short, leaf-like broadest apically. Phallosome with lateral plates and aedeagal sclerites equivalent in length; aedeagal sclerite broad, curved and falciform in lateral view, mostly hyaline, excluding mesal longitudinal sclerotinization and more heavily sclerotinized area at angle of connection with lateral plate, dorsal end narrowly fused to base of lateral plate; lateral plate long, columnar shaped, apical process with blunt and rounded apex, lateral and ventral processes absent, dorsal process sclerotized and separated from margin of aedeagal sclerite by distinct angle; aedeagal sclerites connected by dorsal aedeagal bridge. Proctiger elongate; paraproct distally narrowed, basally expanded, base articulated with posterolateral margin of tergum X, crown with row of about 6 short, simple blades; cercal sclerite long and narrow, sclerotized, broadest basally; 2,3 small cercal setae. Tergum X large, rectangular, concavo-convex, dorsal surface concave.

Material examined.—Sixty specimens examined from several localities in São Paulo State, Brazil, as follows: 41 ♀♀ (Experimental Station, Pariquera-Açú, I.81, XI.81, XII.81, I.82, 12; Biguá Road, Iguape, IX.82, X.82, XI.82, 28; Santa Helena Farm, São João da Boa Vista, XI.81, 1). 19 ♂♂ (Pariquera-Açú, urban area, XI.79, 1; Pariquera-Mirim, Pariquera-Açú, V.85, VI.85, 2; Itapuan, Itapitangui, Cananéia, V.80, XII.80, I.81, II.81, III.81, IV.81, XI.81, 11; Biguá Road, Iguape, X.82, 2; Santa Helena Farm, São João da Boa Vista, III.82. 3) Iguape, Cananéia and Pariquera-Açú, are located between 24.0°–25.0°S and 47.0°–48.0°W, São João da Boa Vista is 22.0°S and nearly 47.0°W.

Distribution and bionomics.—*Culex delpontei* is reported here for the first time from Southern Brazil. It has also been found in Paraguay and Northern Argentina as next related (Duret 1953, 1968; Sirivanakarn and Jakob 1981; Mitchell et al. 1985). Its distribution is in the southern range of subgenus *Melanoconion* (Fig. 13): ARGENTINA.—*Chaco:* Las Palmas (type locality); Puerto Bermejo; Resistencia, San Fernando

Dept.; Antequera, 1 de Mayo Dept.; *Corrientes:* Rincon de Vences, General Paz Dept.; *Santa Fe:* Esperanza, Las Colonias Dept.; San Justo, Sanjusto Dept. PARAGUAY.—Puerto-í, San Pedro Dept.; Toldo-cué, Concepción Dept.; San Pedro, San Pedro Dept.; Puerto Pinasco, Boquerón Dept.

Little is known about the bionomics of this mosquito. Swamps and riversides covered by aquatic plants, such as *Pistia,* may shelter gravid females (Mitchell et al. 1987a). It is assumed that these would also be suitable places for oviposition. In Argentina *Cx. delpontei* was collected with chicken and hamster baits, and one specimen from a horse. Blood meal identification from engorged females showed one fed on an amphibian, a few others on several mammal species (mainly rodents), and two contained a mixture of avian and mammal blood (Mitchell et al. 1987a, b).

As mentioned above, several viral strains were isolated from collected *Cx. delpontei* in Northern Argentina. The Venezuelan equine encephalitis virus subtype VI and several Bunyaviridae were found in this mosquito in the Chaco and Santa Fe Provinces. These findings support it as a possible vector in enzootic patterns of these viruses. In addition, a disproportionate number of virus isolates (18 of 40 in Chaco and 5 of 16 in Santa Fe), suggests the possibility of transovarial transmission (Mitchell et al., 1985, 1987a).

Taxonomic discussion.—*Culex delpontei* was described by Duret (1968) who based his description on adult males from Argentina and Paraguay, including a specimen which he later (1953) identified as *Cx. paracrybda* Komp. Later, Sirivanakarn and Jakob (1981) partially described the female of *delpontei* including a brief reference to the cibarial armature. According to the classification proposed by Sirivanakarn (1982), *Cx. delpontei, Cx. paracrybda* and *Cx. pereyrai,* constitute the Paracrybda Group of the Spissipes Section. Including the characters recognized by Rozeboom and Komp (1950) and Duret (1968) for *Cx. paracrybda,* the distinction among those three species may be made as follows: Scutal and pleural integuments and pleural setae are brown with the scutal and pleural areas not sharply contrasted in *paracrybda,* while there is a well-marked contrast in *delpontei* and *pereyrai* where the pleural integument is yellow or yellowish. In *pereyrai* the pleural integument bears a pattern of dark spots on the upper proepisternum, postspiracular area, prealar knob, lower anterior surface of the mesokatepisternum and an indistinct spot on the upper corner of the mesokatepisternum. In *delpontei* there is no pleural pattern, and this species and *pereyrai* both have shiny yellow to golden pleural setae. The tarsi are entirely dark in *delpontei* while there are pale rings across joints of the tarsomeres and tarsomere 5 is entirely white in *paracrybda* and *pereyrai. Culex ocossa* Dyar and Knab also have pale pleural integument, but this species has a pattern of darker areas on the prealar knob, postspiracular area and lower anterior surface of the mesokatepisternum which separates it from *delpontei.*

In the male genitalia the lateral plate (LP) of both *delpontei* and *paracrybda* have only the apical process which appears as a beaklike hook at the apex in *paracrybda* and is apically blunt and rounded in *delpontei.* Apical, lateral and ventral processes of the lateral plate are present in *pereyrai.* The distal arm of the distal division of the subapical lobe (dSL) has four foliform setae clustered at the apex in *delpontei* and *paracrybda* while in *pereyrai* there is one apical foliform seta and three subapical clustered foliform setae. The proximal arm of the distal division of the subapical lobe (dSL) is enlarged in *delpontei* and narrowed in *paracrybda.* Moreover, the basal seta of the proximal arm is foliform in *pereyrai* while it is saberlike in *delpontei* and *paracrybda.* The slender setae on the basolateral surface of the proximal division of the subapical lobe (pSL) are longer in *delpontei* than in *paracrybda* and *pereyrai*. The ninth tergal lobes are columnar shaped in *delpontei* and *paracrybda* and club shaped in *pereyrai*.

### *Culex* (*Melanoconion*) *pereyrai* Duret
Figs. 7–9, 10, 12, 13

*Culex* (*Melanoconion*) *pereyrai* Duret 1967: 77 (type not seen; type locality Paraguay, Caaguazú, Cecilio Baéz; holotype deposited in the collection of the author specie (Knight and Stone 1977)), Galindo 1969: 88 (tax.). Sirivanakarn 1982: 265 (tax.).

Female.—*Head:* Antenna dark, length about 2.10 mm; flagellum normal, whorls with 6 setae. Proboscis entirely dark-scaled, length 1.63–1.81 mm, mean 1.73 mm. Maxillary palpus entirely dark-scaled, length 0.27–0.37 mm, mean 0.31 mm, about 0.2 of proboscis length. Vertex (Fig. 7) with narrow falcate scales, predominantly pale whitish laterally, dark in small median area, small patch of broad appressed dingy white scales along margin of eye; forked scales numerous, dark; occipital region with some pale whitish falcate scales. *Cibarial armature* (Figs. 8, 9 and 10). Practically indistinguishable from that of *Cx. delpontei*. Surface of cibarial bar not so noticeably folded and sometimes with some thorn-shaped processes on posterior border; cibarial teeth double but posterior part frequently with small thorn-shaped folds on ventral surface. *Thorax:* Scutal integument brown, covered with fine falcate shiny bronze-colored scales, uniform in size, with some pale scales on prescutellar area; scutal setae developed, brownish black with reddish sheen; acrosthical setae absent. Scutellar scales as scutal scales, pale on lateral lobes and entirely dark or mixed with some pale ones on median lobe; lateral lobes each with 4 large setae, median lobe with 6 long setae. Integument of antepronotum similar to scutal integument, without scales and with some dark setae. Postpronotal integument brown with narrow dark scales similar to scutal ones; posterolateral margin with 3–5 dark setae. Pleural integument pale with distinct darker spots on upper proepisternum, postspiracular area, prealar knob, lower anterior surface of mesokatepisternum and an indistinct spot on upper corner of mesokatepisternum. Pleural setae yellowish with golden sheen, brownish black on prealar knob: about 6–11 upper proepisternal, 5,6 prealar, 5–8 upper mesokatepisternal, 7–10 lower mesokatepisternal, 4–8 upper mesepimeral and 1 lower mesepimeral. Pleuron with small patch of pale spatulate scales on lower posterior border of mesokatepisternum. *Wing:* Length 2.80–3.13 mm, mean 2.96 mm; scales dark; length of cell $R_2$ nearly 4.3 of vein $R_{2+3}$; cell $M_2$ nearly 0.8 length of cell $R_2$; subcosta intersects costa at level of furcation of $R_{2+3}$. Dorsal scaling: appressed spatulate scales on costa, subcosta, R, $R_1$, $R_{4+5}$, distal 0.8 of $M_{1+2}$, $M_{3+4}$, Cu, $Cu_1$, $Cu_2$ and proximal 0.5 of 1A; linear plume scales on $R_s$, $R_{2+3}$, M and proximally on $M_{1+2}$; inclined narrow spatulate scales on $R_2$, $R_3$ and on distal 0.5 of 1A; remigium with appressed spatulate scales and 1,2 long distal setae. Ventral scaling: appressed spatulate scales on costa, subcosta, $R_s$, $R_{2+3}$, proximal 0.2 of $R_2$ and $R_3$, M and proximal 0.2 of $M_{1+2}$; linear plume scales on proximal 0.5 of $R_1$, proximally on $R_{4+5}$, proximal 0.5 of $Cu_1$, $Cu_2$ and middle of 1A; inclined narrow spatulate scales on distal 0.5 of $R_1$, proximal 0.8 of $R_2$ and $R_3$, $R_{4+5}$, distal 0.8 of $M_{1+2}$, $M_{3+4}$, distal 0.5 of $Cu_1$, and distal part of 1A; Cu and proximal 0.5 of 1A without scales. *Halter:* Entirely pale. *Legs:* Anterior surface of forecoxa dark-scaled; anterior surface of mid- and hindcoxae with longitudinal patch of nearly colorless scales. Antero- and posteroventral surfaces of foretrochanter dark-scaled, mid- and hindtrochanters with antero- and posteroventral surfaces pale-scaled. Fore- and midfemora mainly dark-scaled, posterior surface of forefemur with indistinct longitudinal stripe of dingy pale scales, posteroventral surface of midfemur with dingy pale scales, hindfemur

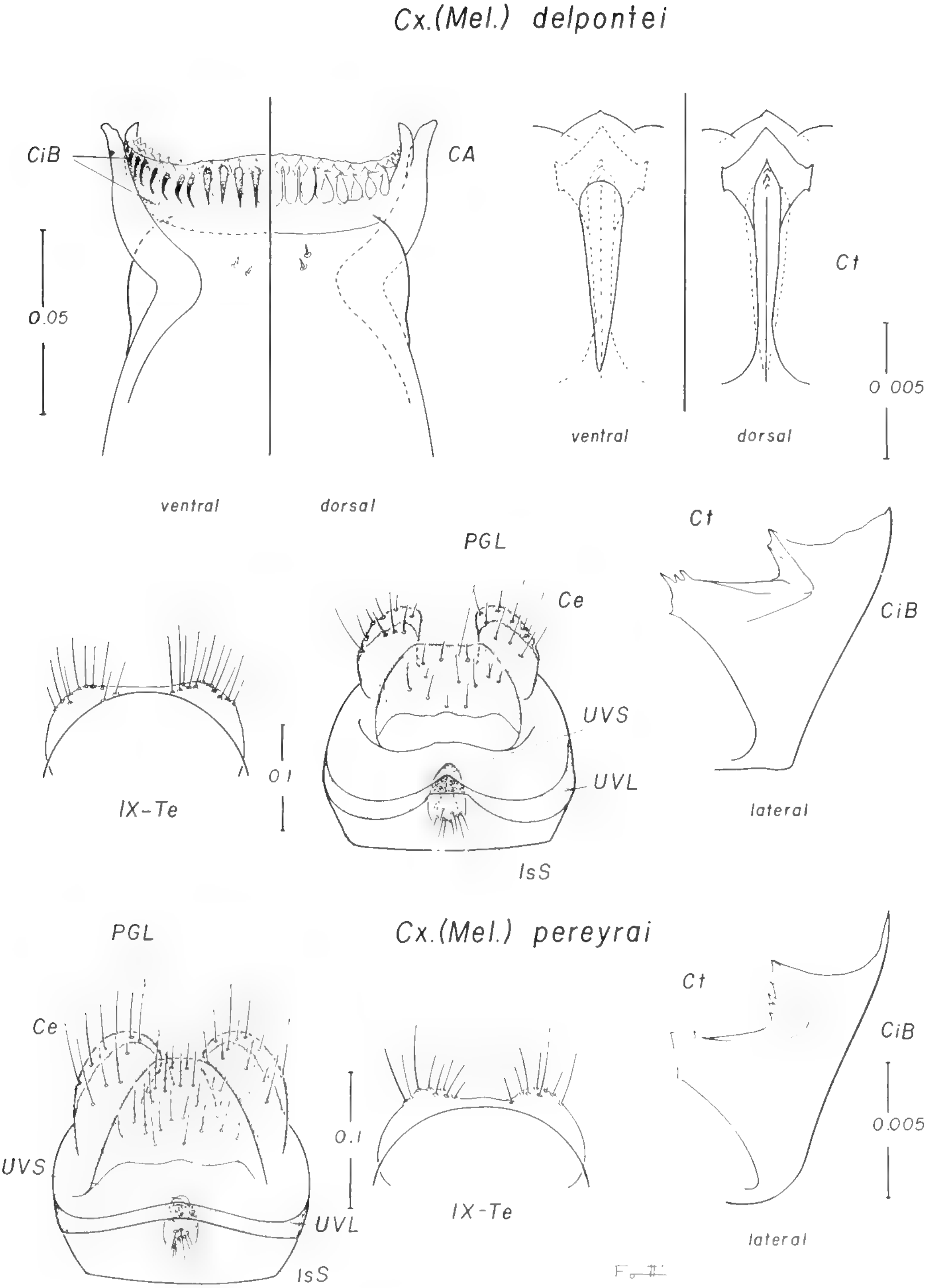
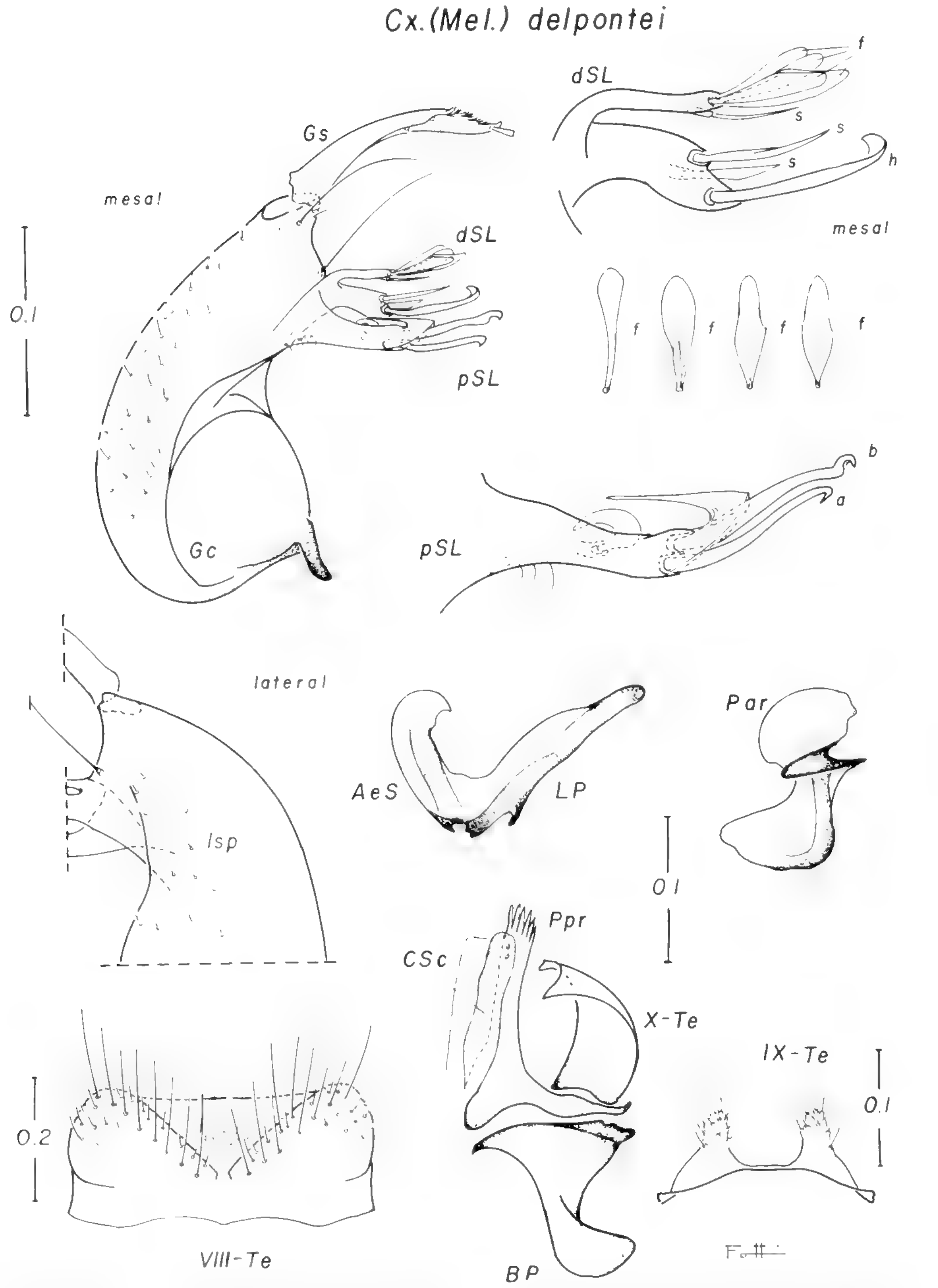
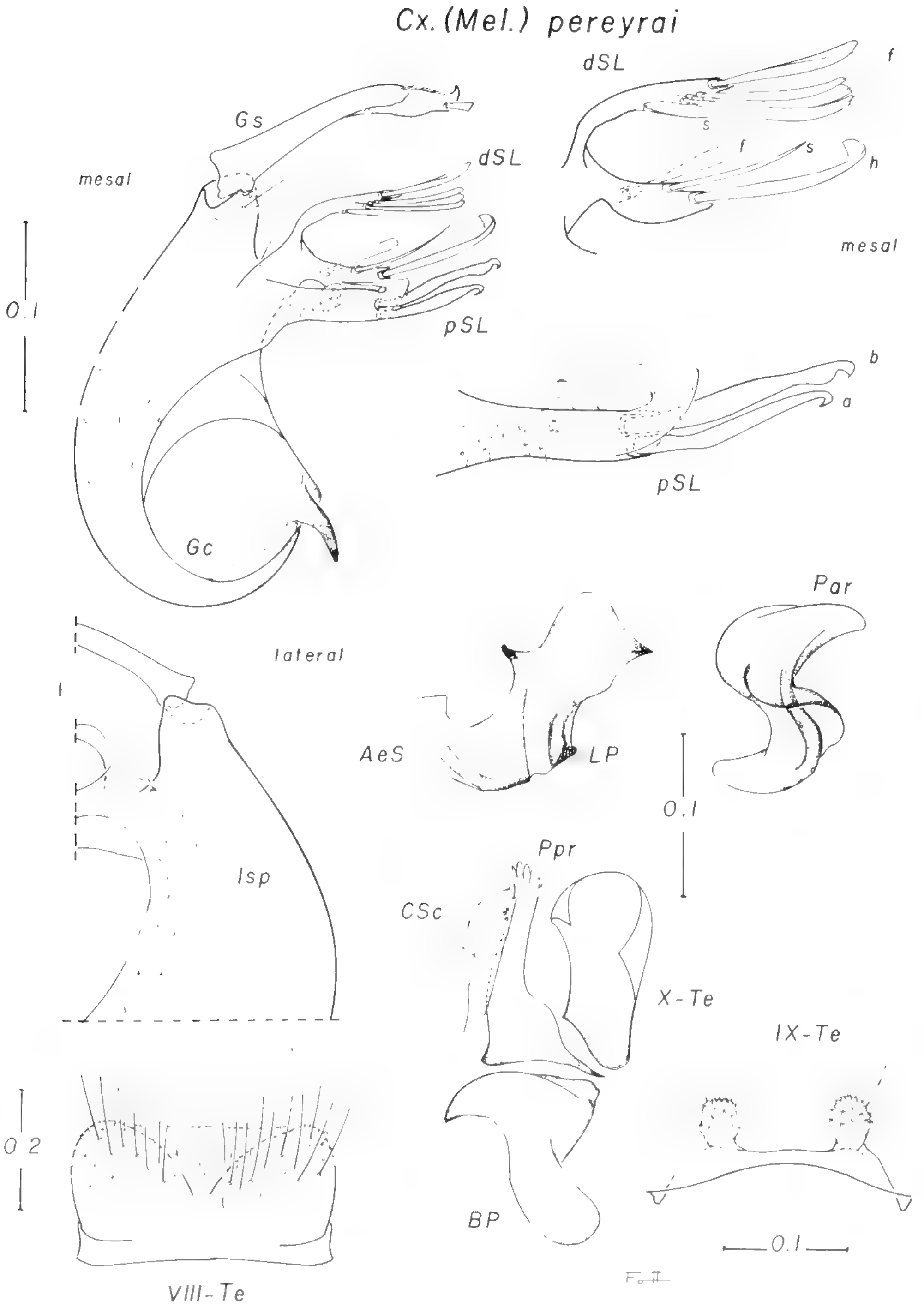


Fig. 10. Female cibarial armature and genitalia of *Culex delpontei* and *Cx. pereyrai*. CA, cibarial armature. Ce, cercus. CiB, cibarial bar. Ct, cibarial tooth. IsS, insular setae. PGL, postgenital lobe. UVL, upper vaginal lip. UVS, upper vaginal sclerite. IX-Te, tergum IX. (Scale in mm.)



Figs. 11 and 12. Male genitalia of *Culex delpontei* and *Cx. pereyrai*. a, seta *a* of pSL. AeS, aedeagal sclerite. *b* seta *b* of pSL. BP, basal piece. CSc, cercal sclerite. dSL, distal division of the subapical lobe. f, foliform seta. Gc, gonocoxite. Gs, gonostylus. h, hooked seta of dSL. lsp, lateral setal patch. LP, lateral plate. Par, paramere.



Ppr, paraproct. pSL, proximal division of the subapical lobe. s, saberlike seta. VIII-Te, tergum VIII. IX-te, tergum IX. X-Te, tergum X. (Scale in mm.)

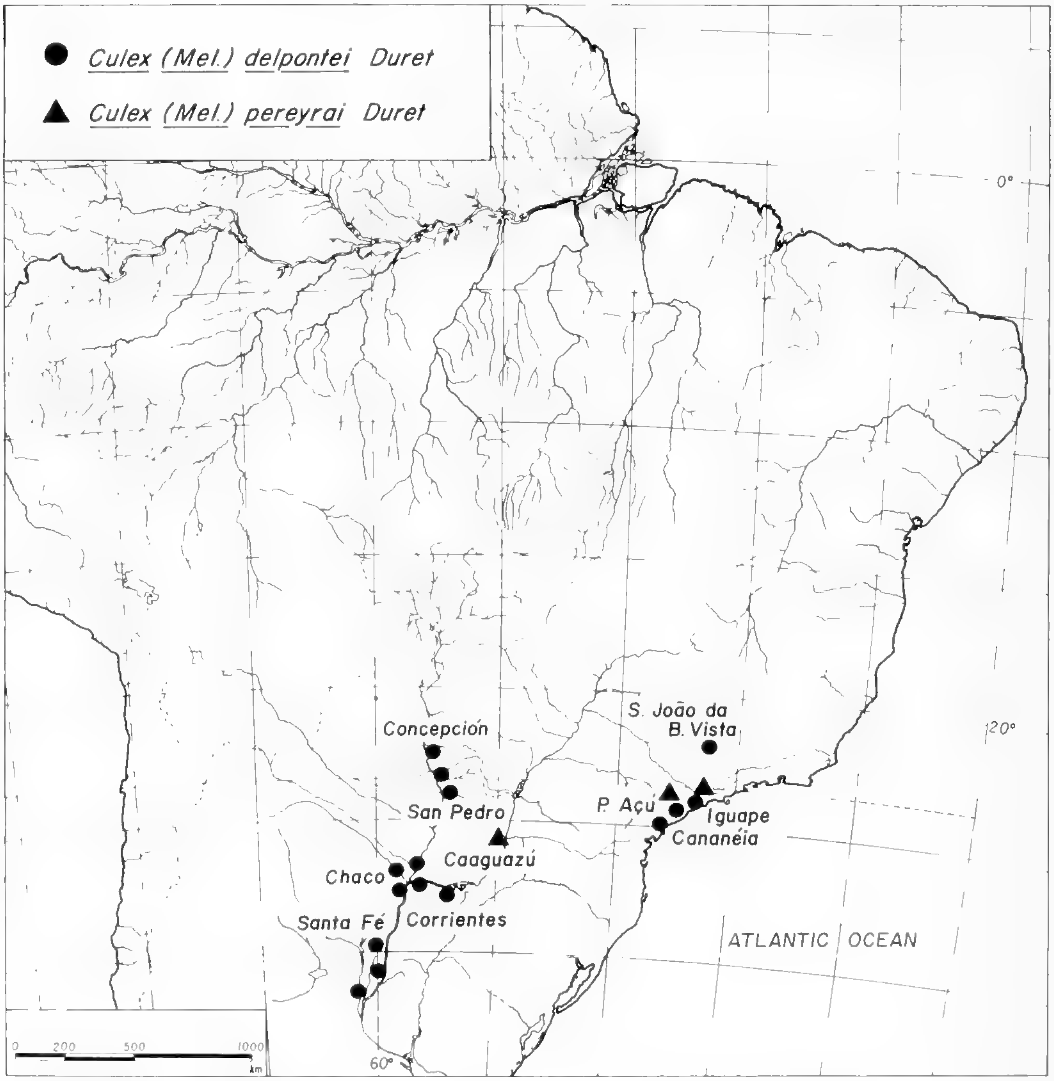


Fig. 13. Distribution of *Culex delpontei* and *Cx. pereyrai* in South America.

with complete dorsal stripe of dark scales distally widening and expanding onto anterior and posterior surfaces at apex. All tibiae with indefinite longitudinal dingy pale stripe of scales on posterior surface. Ta-I$_1$ and Ta-II$_1$ with indistinct longitudinal dingy pale stripe on posterior surface, more evident at apex, Ta-I$_2$–Ta-I$_4$ and Ta-II$_2$–Ta-II$_4$ with indefinite pale bands on joints, Ta-I$_5$ and Ta-II$_5$ paler, hindtarsus with distinct narrow basal and apical white bands at joints of tarsomeres 1–4, Ta-III$_5$ entirely white. *Abdomen:* Tergum I with median posterior patch of dark scales, tergum II dark-scaled with small basolateral patches of white scales, terga III–VIII dark-scaled with basolateral patches of white scales, sometimes appearing as narrow basal pale bands on terga IV–VI, bands more evident on IV and V. Sterna II–VII with broad basal white bands, sternum II sometimes entirely white-scaled; sternum VIII with lateral patches of white scales, occasionally mixed with some dark ones. *Genitalia* (Fig. 10): Tergum IX narrow at middle, widened at posterolateral margin to produce flat lobe bearing 7–9 slender setae. Upper vaginal lip distinct, narrow; lower vaginal lip and insula indistinct, insula with about 7–9 clustered setae. Upper vaginal sclerite discrete, with inverted U-shape. Postgenital lobe short, distally with 10–17 setae on either side of midline, mostly on ventral surface.

Male.—Like female except for sexual differences as follow. *Head:* Antenna strongly plumose; length about 1.77 mm. Proboscis and maxillary palpus entirely dark, palpus length about 2.62 mm, exceeding proboscis tip by length of palpomere 5 and 0.9 of palpomere 4; palpomeres 4 and 5 densely setose; palpomere 3 with 6–8 apical setae. *Abdomen:* Tergum II entirely dark-scaled or with few white scales on basolateral areas; terga III–V with basal white bands; terga VI, VII not examined; tergum VIII (ventral in position) with basolateral white patches, deep V-shaped median posterior emargination and several long bristles mixed with shorter setae (Fig. 12); sternum II with white scales mixed with some dark ones; sterna III–V with basal white bands; sterna VI–VIII not examined. *Genitalia* (Fig. 12): Ninth tergal lobes small, slightly globose, club-shaped, widely separated, bearing long and slender setae. Gonocoxite stocky, outer margin convex, inner moderately concave; ventrolateral surface with strongly developed setae, mesal surface with small setae in indistinct rows extending from base to level of subapical lobe, lateral surface with patch of sparse short and slender setae (lsp) at proximal region up to level of subapical lobe, proximal part of ventrolateral surface with 1,2 scales; subapical lobe distinctly divided, divisions approximated; proximal division not divided, lengthened, with an apical infundibular and hyaline expansion partially covering insertions of setae *a* and *b* (setae *a* and *b* long and sinuous) with another hyaline, broad and hooked-falciform seta beyond middle, and 9–14 short, slender and curved setae from base to level of insertion of hooked-falciform seta; distal division with 2 fairly well separated uneven arms, proximal one stronger, bearing 1 long hooked seta (*h*), 1 saberlike pointed seta (s) and 1 shorter foliform seta (f) inserted on prominent tubercle near middle of arm; distal arm slender, cylindric, bearing 1 stiff, short, nearly saberlike seta (s) inserted near middle of arm, 3 foliform setae (f) on distal 0.3 of arm, 1 longer nearly foliform seta (f) inserted separately at tip of arm. Gonostylus slender, curved, moderately narrowed distally, crest slightly wrinkled on ventral surface before apical snout; gonostylar claw short, leaflike, apically broadest. Phallosome with lateral plates and aedeagal sclerites equivalent in length; aedeagal sclerite broad, curved and falciform in lateral view, more sclerotized area at angle of connection with lateral plate and at mesal longitudinal sclerotinization, dorsal end narrowly fused to base of lateral plate; distal part of lateral plate with apical, ventral and lateral processes, apical process short, broad at base, rounded at apex, ventral process curved laterally, lateral process slender, nearly pointed and dorsolaterally directed, dorsal process sclerotized and separated from aedeagal sclerite margin by distinct angle; aedeagal sclerites connected by dorsal aedeagal bridge. Proctiger elongate; paraproct narrow distally, expanded basally, base articulated with posterolateral margin of tergum X, crown with row of 5–7 short simple blades. Cercal sclerite long and narrow, sclerotized, broadest basally; 3,4 small cercal setae. Tergum X large, rectangular, concavo-convex, dorsal surface concave.

Material examined.—Fifty-five specimens examined from localities in São Paulo State, Brazil, as follows: 25 ♀♀ (Experimental Station, Pariquera-Açú, II.79, XII.79, IV.80, VIII.80, XI.80, XII.80, I.81, II.81, III.81, IV.81, VI.81, 13; Biguá Road, Iguape, X.82, XI.82, 12). 30 ♂♂ (Experimental Station, Pariquera-Açú, I.80, II.80, IV.80, XI.80,

II.81, III.81, IV.81, V.84, VII.84, V.85, 25; Pariquera-Mirim, Pariquera-Açú, VII.84, I.85, V.85, 3; Biguá Road, Iguape, X.76, 2).

Distribution and bionomics.—Until now, *Cx. pereyrai* was known only from the male holotype (type locality Paraguay, Caaguazú, Cecílio Baéz). The collections reported here extend its distribution to the localities in southern Brazil (Fig. 13).

Nothing is known about the larval habitats and little data are available about the adult habits. The collections reported here were made in patches of residual forests in modified rural areas. A few specimens were caught near houses.

Taxonomic discussion.—*Culex* (*Melanoconion*) *pereyrai* was described by Duret (1967) based on one adult male from Paraguay. Additional specimens of this species were unavailable until now. Sirivanakarn (1982) placed this species in the Paracrybda Group of the Spissipes Section where itself constitutes the Pereyrai Subgroup. The distinction with *Cx. delpontei* Duret and *Cx. paracrybda* Komp has already been discussed.

Since *Cx. pereyrai* has Ta-III$_5$ entirely white, distinction must be made with other species of the Spissipes Section that share this character as *Cx. epanastasis* Dyar, *Cx. pedroi* Sirivanakarn and Belkin, *Cx. sacchettae* Sirivanakarn and Jakob and *Cx. taeniopus* Dyar and Knab. Including the characters noted by Sirivanakarn (1978) and Sirivanakarn and Belkin (1980), distinction can be made as follows.

The pale pleural integument with a pattern of darker spots, separates *pereyrai* from *epanastasis, pedroi* and *taeniopus* which have an entirely dark integument. From *sacchettae,* which also has a pale pleural integument, distinction can be made by the darker spots on the upper corner of the mesokatepisternum and on the mesepimeron which *pereyrai* lacks. In addition, *taeniopus* has a cluster of pale scales on the upper corner of the mesokatepisternum, while *epanastasis* and *pedroi* have clusters of white scales on the femoral apices, characters absent in *pereyrai.*

The female cibarial armature of *pereyrai* is quite similar to that of *delpontei* and *Cx. ocossa* Dyar and Knab. The latter two species are distinguished by the absence of pale bands on the legs.

Finally, it is interesting to note that the male genitalia of *pereyrai* is similar not only to *delpontei* and *paracrybda,* but also to *Cx. adamesi* Sirivanakarn and Galindo, *Cx. crybda* Dyar, *epanastasis, pedroi* and *Cx. ribeirensis* Forattini and Sallum. In all the species the subapical lobe of the gonocoxite has an infundibular process and one hook-shaped seta on the proximal division and the distal division is subdivided into two arms, the proximal one with 3 setae and the distal one with 4 setae.

## ACKNOWLEDGMENT

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# BOOK REVIEW

*The Fleas of the Pacific Northwest,* by Robert E. Lewis, Joanne H. Lewis, and Chris Maser. Oregon State University Press, Corvallis, OR. [viii] + 296 pp. 1988. $49.95/cloth (alkaline paper). ISBN: 0-87071-355-8.

The fleas (order Siphonaptera) of the Pacific Northwest are better known than those of any other section of the continental United States save California and Utah. However, not since C. A. Hubbard's *Fleas of Western North America* (1947) has an attempt been made to survey this region's rich fauna. Robert Lewis is a respected taxonomist who oversees a splendidly curated flea collection at Iowa State University. Together with his talented wife Joanne, he has edited and published a helpful newsletter on fleas since 1980. The present opus, initially entitled *The Fleas of Oregon and Their Importance in Public Health* (but expanded on the eve of press time to include the surrounding territory), owes its existence to the Lewises' long collaboration with Oregon naturalist Chris Maser. It is at once a monumental yet unaccountably incomplete work.

Certainly the book invites perusal. Clothbound in imitation leather, with lavish gold lettering on the covers and spine, it opens by paying due homage to Canada's gentleman-scholar of Siphonaptera, the late George Pearson Holland, whose beautiful drawings of flea anatomy account for 198 of the 268 text figures in the book. There follows an introduction to flea life history and morphology that is concise but lucid and includes a complete glossary of abbreviations used in the keys and illustrations. There is also a brief but well-documented discussion of flea-borne disease that covers bacterial, rickettsial and viral agents, as well as tungiasis and transmission of cestodes.

The body of this work (pp. 23–257) is devoted to a systematic review of the 6 families, 54 genera, and 161 species and subspecies of fleas that Lewis recognizes as occurring in the Pacific Northwest. Surprisingly, the boundaries of this region are never defined—probably because the authors realize that they are not dealing with a biogeographic unit—but the little dot distribution maps that accompany each species description imply that coverage embraces not only all of Oregon and Washington but also California north of San Francisco Bay, the western strip of Idaho counties from that state's panhandle southward, and the whole of Nevada except Clark County (i.e. everything but Las Vegas). In no other work that this writer has seen is "Pacific Northwest" given such latitude. The maps themselves are worthless, having been based on Maser's collecting itinerary and an arbitrary selection of literature records. The text's best features are its keys. I have tested the key to families and find it easy to use, despite the well-known absence of prominent familial characters in this order. Similarly, keys to genera, species and subspecies employ structures that can be readily found by a nonspecialist and that are defined and illustrated in the introduction. The detailed aedeagal terminology of Traub (1950, Fieldiana: Zool. Mem. 1: 1–127) is referenced but (fortunately for the layman) not discussed. The book concludes with a depauperate bibliography of only 120 references (about half the literature for this area), a woefully incomplete host/flea index (Appendix I), a lengthy discussion of how to mount fleas on microscope slides coupled with an inadequate survey of collecting techniques (Appendix II), but a thoroughly orchestrated index to all scientific names of flea taxa cited in the text, including junior synonyms and invalid names or combinations.

This work is fatally flawed on two counts, of which the most damaging is its multiplicity of omissions. Contrary to Lewis's assertion (p. 18) that "there have been relatively few publications dealing with the fleas of the area," the literature for the Northwest is both extensive and diverse, ranging from basic taxonomy to investigations of adult and larval population dynamics, host specificity, and even population modeling. Moreover, at least one graduate student at Oregon State University successfully conducted an intensive study of fleas associated with small mammals throughout Oregon's vast Willamette Valley. When even the theses on file at the school responsible for publishing this book are not consulted, I can only conclude that I am witnessing an exercise in arrogance rather than objective science.

A review is not the forum for revising an imperfect work, but some effort must be made to plug a *few* of this book's numerous gaping lacunae. Thus, under *Atyphloceras multidentatus* (C. Fox) (pp. 66–67), we find no mention of the remarkable ecology of this hystrichopsyllid in the northern Sierra Nevada of Plumas County, California (Jameson and Brennan, 1957, Ecol. Monogr. 27: 45–54). There, *A. multidentatus* is abundant on the deer mouse *Peromyscus boylii* (Baird) and common on *P. maniculatus* (Wagner) in brushy field situations. However, in coniferous forests (where *P. boylii* rarely occurs), *A. multidentatus* is seldom found on *P. maniculatus* but is frequent on the microtine *Clethrionomys californicus* (Merriam). Therefore, while *P. maniculatus* is a satisfactory host, the degree to which it is parasitized appears to be largely dependent on habitat. Similar observations have been made by Russian siphonapterists, but perhaps Lewis et al. do not have access to translations. Further, *A. multidentatus* is a capable vector of plague, having been successfully infected experimentally (Eskey and Haas, 1939, Publ. Hlth. Rep. 54: 1467–1481) and found able to transmit the disease (Prince, in Wayson, 1947, Publ. Hlth. Rep. 62: 780–791). This flea should also be added to Lewis's host/flea index under the shrew *Sorex vagrans* Baird and the vole *Microtus canicaudus* Miller (Robbins, 1983, J. N.Y. Entomol. Soc. 91: 348–354, and references cited therein).

Lewis's statement (p. 82) that *Catallagia charlottensis* (Baker) is "not a conspicuous element" in the flea fauna of the Northwest is contradicted by Hubbard (op. cit.) and other specialists familiar with this area (Vernon J. Tipton, Brigham Young University, personal communication). In western Oregon, *C. charlottensis* can be collected by the thousands from a broad range of small mammals during all months of the year. Once again, Jameson and Brennan's observations on ecological segregation are ignored, nor is there any indication of the role of *Catallagia* species in plague transmission (for which, see Anonymous, 1950, Publ. Hlth. Rep. 65: 614; Allred, 1952, Gr. Basin Nat. 12: 67–75; Beck, 1955, Brigham Young Univ. Sci. Bull. 1: 1–37; and Kartman and Prince, 1956, Amer. J. Trop. Med. 5: 1058–1070). Add *C. charlottensis* to Lewis's host/flea index under *Sorex vagrans,* and add *C. sculleni* Hubbard under *Microtus canicaudus.*

Another mistreated hystrichopsyllid is *Corrodopsylla curvata* (Rothschild), which is erroneously held to "show no particular peak in seasonal abundance" (pp. 137–138) when in fact samples from 3 different test sites in western Oregon all showed spring and early winter population maxima (Faulkenberry and Robbins, 1980, Entomol. News 91: 93–101). For some unknown reason, Lewis cites Hansen's (1964, Gr. Basin Nat. 24: 75–81) collection of *C. curvata* from the Steens Mountain area of Harney County, Oregon, without adding the host, *Sorex palustris* Richardson, to his host/flea index. *Corrodopsylla curvata* is also a regular accidental on *Microtus canicaudus* in western Oregon.

Under *Hystrichopsylla occidentalis* Holland (p. 64), we find the claim that "there are no published records of this species being associated with the transmission of disease." However, as a rule, members of the genus *Hystrichopsylla* are capable and efficient plague vectors and frequently are involved in maintaining epizootics (Eskey and Haas, op. cit.; Prince, in Wayson, op. cit.; Anonymous, 1950, Publ. Hlth. Rep. 65: 1174; and Kartman and Prince, op. cit.). Add this species to the host/flea index under *Microtus canicaudus.*

The ubiquitous ceratophyllid *Aetheca wagneri* (Baker) is mistakenly missing from Lewis's host/flea index under *Sorex vagrans, Microtus canicaudus,* and *M. townsendii* (Bachman), despite the existence of scores of collections from these animals. Worse is the fate of another ceratophyllid, the northern (or European) rat flea, *Nosopsyllus fasciatus* (Bosc), which was dismissed from Maser's surveys because "we were concerned with the parasite fauna of endemic birds and mammals and no effort was made to collect domestic rats and mice" (p. 200). In disowning this species, which has long been recognized as a capable and moderately efficient plague vector (McCoy, 1911, Publ. Hlth. Bull. 43; Bacot and Martin, 1914, J. Hyg. 13: 423–439; Bacot, 1915, J. Hyg. 14: 774–776; Eskey and Haas, 1940, Publ. Hlth. Bull. Wash. (254): 1–83; and Burroughs, 1947, J. Hyg. 45: 371–396) and which may have played a secondary role in maintaining the great 14th century European plague pandemic (Pollitzer, 1954, *Plague*), the authors nullify their principal justification for writing, namely that "public health workers are exposed to fleas and other disease vectors during the course of their work" (Introduction, p. 1). Needless to say, *N. fasciatus* should appear in the host/flea index under several native mammals, among them *Peromyscus maniculatus, Microtus canicaudus,* and *M. townsendii.*

Hubbard's (op. cit.) claim that the leptopsyllid *Peromyscopsylla selenis* (Rothschild) is most numerous in the fall, winter and spring has been repeatedly corroborated (Robbins, op. cit.). Lewis's single late summer peak (p. 143) is probably the result of sampling error. Add *Microtus canicaudus* to the host list on p. 142.

Readers seeking information on flea ecology will have to look to other texts, for Lewis et al. make no effort to summarize the wealth of published data on flea populations in the Pacific Northwest. Only a smattering of lost opportunities can be listed here, among them: correlation of flea population fluctuations with meteorological variables, host phenology, or host attributes (e.g. sex, size, age); application of uniform indices of extensity and intensity, such as those introduced by Janion (1968, Ekol. Polska (A) 16: 561–606) and refined by Lundqvist (1974, Entomol. Scandinavica 5: 39–48); analysis of flea sex ratios (an entire subset of ectoparasitological literature has developed around this one subject!); and computerized population modeling (Robbins and Faulkenberry, 1982, Entomol. News 93: 70–74).

Beyond these multifarious errors of omission lies a second, subtler failing: the absence of what in another context has been called the "life spark." Those of us who have had the unspeakably good fortune to sit mesmerized at the feet of Robert Traub, the world's foremost authority on Siphonaptera, will know what I mean. Traub's 85 peerless publications on fleas, which his spiritual brother the late Karl Jordan called "these jolly insects," are alive with anecdotes drawn from all corners of the earth. Who can tell how many graduate students have been inspired by Traub's work? His writing is musical; there is Ketèlbey in the fauna of Egypt, Grofé in America. Of all the omissions in Lewis's book, it is this music—this romance—that I miss most. Had Maser taken the time to collect mammal nests and extract their fauna using Berlese-Tullgren funnels (a technique that was completely overlooked), he would have found, among other wonders, ticks in all life history stages, phoretic deutonymphs of uropodid mites attached to adult fleas via anal pedicels, innumerable flea larvae awaiting correlation with adults of their species, nidicolous carabid and staphylinid beetles that prey on flea larvae and thereby regulate larval populations, and exquisite aphodiine scarabs (e.g. *Aphodius cribratulus* A. Schmidt, *A. haemorrhoidalis* Linnaeus, and *A. pardalis* LeConte) that complete their metamorphoses only in the nest chambers of burrowing mammals. Music.

I said at the outset that this is a monumental book: it is large, eye-catching, and will probably achieve some recognition on the entomological horizon. But if flea texts could aspire to the status of skyscrapers, this one would remind me of nothing more than the World Trade Center in Lower Manhattan, into whose brazen towers the demolition plans have already been built. And if I were to summarize my feelings about this book, I could do no better than defer to the brilliant architecture critic Paul Goldberger of *The New York Times* who, in addressing the dilemma of the towers, remarked "if they say anything at all . . . it is that we retreat into banality when the opportunity comes for greatness."

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# BOOK REVIEW

*Outlines of Entomology.* R. G. Davies 1988. Seventh Edition. Chapman and Hall, London, New York; viii + 408 pp. $37.50 Softcover, ISBN 0 412 26680 6; $75.00 Hardcover, ISBN 0 412 26670 9.

This textbook is the newly-revised, condensed version of Imms' General Textbook of Entomology by Richards and Davies, and replaces the sixth edition of "Outlines." The seventh edition has been considerably expanded, with new material on modes of life in insects, a new chapter on the biology of insect populations, and a new section on injurious insects and pest management. The book is designed to be an introduction to the field of entomology for biological science students and those in related agricultural fields.

The introductory chapter briefly discusses the general characteristics of insect structure, diversity, life histories, and habits. A chapter on insect structure and function deals with basic external and internal anatomy and morphology, insect flight, respiration, circulation, and reproduction. The following chapter treats development and metamorphosis. A chapter on classification and biology treats insects at the ordinal level. A diagnosis is given for each order, followed by a summary of the principal structural features that are used in identification and classification, habits, and habitats where representatives are found. For larger orders, major subdivisions and groups of families are also discussed. A chapter on the evolutionary relationships of insects discusses the fossil record of insect groups, and summarizes theories regarding relationships between orders or groups of orders, with emphasis on recent information. A chapter on modes of life in insects deals with how insects make a living, including the structural, functional and behavioral adaptations to different environments and lifestyles, with sections on insects and plants, pollination, insects and micro-organisms, predators, parasitoids and parasites, aquatic insects, mimicry and protective coloration, and social insects. This is followed by a chapter on the biology of insect populations which treats characteristics of population growth, regulation, life tables, key factor analysis, resource partitioning, predator-prey relationships, food webs and the trophic structure of communities, diversity, stability and succession, and genetic diversity. A chapter on the economic importance of insects gives representative examples of the kinds of pest insects, the nature of damage they cause, methods of control by insecticides, biological control, and integrated pest management. A classified bibliography is subdivided by subject area, and includes references that the reader can consult for additional information. References up to 1987 are included.

This textbook is an excellent introduction to the field of entomology, and fulfills the objective of the author to present the basics of entomology, no mean task for a discipline so large and diverse. The information presented is generally up-to-date. The text is very well-written, readable, and the illustrations, with one or two exceptions, are clearly labelled and easy to interpret, and complement the text well. The classified bibliography is especially useful, being current, comprehensive, and providing an excellent beginning point for readers who wish to pursue particular topics further. The clarity of the text and illustrations make this book suitable for readers with no special scientific background, as well as for students in the sciences.

The major criticism I have of this book is the continued use of an archaic system of higher classification. The author presents an excellent discussion of the higher classification of insect orders in the section on evolutionary relationships, but justifies the use of a long-outmoded system of ordinal classification, unwisely in my opinion, with the statement that there is "substantial disagreement" about some features of insect phylogeny. In fact, there is substantial agreement about many aspects of insect phylogeny, and the classification used in a modern textbook on entomology should reflect a "phylogenetic" classification when there is a firm basis for it. While one might quibble over the use of particular ordinal names, I would prefer the use of Microcoryphia and Thysanura for the bristletails and silverfish, respectively, with the names Archaeognatha and Zygentoma reserved for the respective infraclasses to which these orders are assigned. I also prefer the use of Notoptera in preference to Grylloblattodea for the mountain crawlers. The Isoptera should be subsumed under the Dictyoptera, along with the mantids and roaches, consistent with current thinking, particularly in view of the author's statement that "the members of this order [Isoptera] are structurally very similar to the Blattaria." The author acknowledges that the Neuroptera, as treated in this text, is a "rather heterogeneous order . . . ." Both the Megaloptera (fishflies, dobsonflies and alderflies) and the Raphidioptera (snakeflies) represent distinct lineages and should be treated as separate orders.

Inevitably, in a text of this breadth, there will be minor problems of correct usage of names, inadvertant misstatements, and misleading generalizations. A sample of these is given without intending to detract from the general excellent quality of the text. There are remarkably few typographical errors in the text: Plannipennian for Planipennian (p. 65), *Borellia* for *Borrelia* (p. 315), *Toxirhynchites* for *Toxorhynchites* (p. 337), and *hominovorax* for *hominivorax* were the only ones I found. Several old names are still found in the text: *Psilopa* = *Helaeomyia* (p. 2), *Taeniorhynchus* = *Mansonia* (p. 76), *Culex fatigans* = *C. quinquefasciatus* (p. 319), *Reesimermis nielseni* = *Romanomermis culicivorax* (p. 337). The use of *Tabanus rusticus* Linnaeus to illustrate a valid binomen (p. 116) is inappropriate since *rusticus* is now placed in *Atylotus*. Use of another binomen, such as *Tabanus bovinus* Linnaeus, to illustrate a valid, original Linnean binomen would be more satisfactory, with *Atylotus rusticus* (Linnaeus) as an example of a species name transferred from its original genus to another. I would prefer the use of the term binominal nomenclature instead of binomial nomenclature (p. 116) to minimize confusion with mathematical terminology.

There are a few minor errors of fact. Cyclorrhaphan Diptera have 3 preimaginal instars, not 4 (p. 106), unless one includes the puparium, but this is not clear in the text; Grylloblattodea (Notoptera) are carnivorous and predators, not omnivores (p. 132), as clearly demonstrated by Pritchard and Scholefield (1978); *Stomoxys* is inappropriately called the "biting house fly" (p. 165), but more precisely the stable fly later in the text; *Sarcophaga* is not a blow fly (p. 214), but a flesh fly; visceral leishmaniasis occurs in the New World as well as in the Old World (p. 323).

A few generalizations by the author are inappropriate or misleading to the reader. Although many dipteran larvae pass through 3 or 4 instars (p. 166), most orthorrhaphan Brachycera larvae have several additional instars; the statement that "syrphids feed largely on aphids" (p. 221) should refer more appropriately to the Syrphinae; not only do the males and females of *Stomoxys* feed on blood (p. 230), so do both sexes of all Stomoxyinae (*Haematobia, Haematobosca* etc.).

Occasionally, the author has failed to incorporate useful new information into the text or uses curiously archaic terminology. The discussion on the origin of wings in insects (p. 25) is very superficial and includes none of the recent evidence on alternative theories of the origin of wings in insects, touting instead the thoroughly discredited paranotal lobe theory. This is especially puzzling since the author includes pertinent references by Kukalova-Peck, for example, in the selected bibliography. Use of the term "Protozoa" throughout the text instead of Protista (or Protoctista) does not reflect current usage of Kingdom-level classification in introductory biology texts or the scientific literature. The treatment of morphogenesis (p. 111–112) is seriously out-of-date. No mention is made of the dramatic advances in understanding the morphogenesis of *Drosophila,* with information on pattern formation, the mosaic vs. regulative models, importance of diffusible morphogens and chemical gradients, progress zones, homeoboxes, and the role of regulatory gene centers in specifying differentiation of the developing embryo. The Order Trichoptera has about 11,000–12,000 described species, not "less than 3,000" (p. 175). The term "Siphunculata" (p. 230) for the sucking lice (Anoplura) is archaic. Use of "Culicinae" (p. 230 and elsewhere) to refer to mosquitoes is archaic, since the Dixidae and Chaoboridae are generally considered separate families. The pathogens causing sleeping sickness in humans in Africa are *Trypanosoma brucei gambiense* and *T. brucei rhodesiense.* The *brucei* group is now associated with human trypanosomiasis, not nagana (p. 322). In addition to the blood-sucking insects discussed (p. 230–232), the curious blood-feeding Lepidoptera of the genus *Calyptra* (Noctuidae) should be mentioned. A more precise, succinct definition of pest management in the section on integrated pest management would be useful to the uninitiated reader. The definition given in Rabb and Guthrie (1970, p. 2–3) is an excellent one.

Two general comments are in order. Some of the common names of insects used in the text may be unfamiliar to entomologists in North America, who are more familiar with the Entomological Society of America (ESA) list of common names. Perhaps this is inevitable in a text written outside of North America. The cost of the hardcover edition of this text ($75.00) is far too high for an introductory text, and far higher than the prices of other introductory entomology texts in hardcover available in North America ($39.00–$48.00). The quality of this text is not sufficiently superior to others of its genre to justify paying double the price of others. The paperback edition, however, is priced comparably ($37.50) with other introductory texts.

In summary, this is an excellent introduction to the field of entomology. It is well-written, clearly illustrated, and highly recommended as a text for those interested in a general introduction to insect biology, classification, the importance of insects in the natural environment, and the importance of insects to humans.

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# BOOK REVIEW

*Silent Spring Revisited.* G. J. Marco, R. M. Hollingworth and W. Durham [eds.]. American Chemical Society, Washington, D.C., 1987, xviii + 214 pp., $17.95.

That Rachel Carson's book *Silent Spring* was controversial is unrefutable. That all the predictions and statements were correct is questionable. That the book is important is a fact. *Silent Spring Revisited* is based upon a symposium organized to "address the issues that Rachel Carson raised and to focus on their pertinence for the past, present and future." The contributors provided an excellent cross-section of opinions on all sides of the issues—though the bias of the authors usually was evident.

Shirley Briggs, of the Rachel Carson Council, Inc., starts with a discussion of the vision and legacy of Ms. Carson. Briggs discusses Carson's motives, the reaction to *Silent Spring,* and then goes on to the comprehensive view. She states that, "We at Rachel Carson Council have yet to be shown a valid example" [of inaccuracies or mistakes]. G. K. Kohn of Zoecon Corp., in chapter 10 points out some of the inaccuracies, though recognizing Carson's achievements. Kohn's chapter is an excellent balance to the conflicting values of a pragmatic approach to agricultural productivity and the preservation of the environment. John Moore of EPA reviews the evolution of government regulations. He states that, "the extensive requirements for current regulation do not always provide clear insight as to appropriate action. For example, the technical capability to routinely analyze in parts per million, billion, trillion or quadrillion clearly surpass the toxicologists' and other scientists' ability to confidently interpret human or environmental risk." Unfortunately EPA gets blamed for not doing enough by environmental zealots and for being over zealous by the producers and users of pesticides. It may be of interest to note that the National Agricultural Chemical Association estimates the cost and time of developing a pesticide, from the test tube to the market, to be $40 million and 8 years. Most of this is to fulfill EPA testing requirements.

C. F. Wilkinson of Cornell University continues the discussion in a chapter on the science and politics of pesticides. He very succinctly states, "For the last decade and a half an emotional belief, often verging on hysteria, has existed in the United States that society is being not so slowly poisoned by pesticides and other products of modern chemical technology. Despite the facts that we live longer and generally enjoy a much better quality of life than at any other time in our history, we have become a society consumed with fear and obsessed by the risks in our lives." Wilkinson then discusses the regulatory decision-making process; toxicology—a science and an art; toxicological evaluations; assessment of acute toxicity; carcinogenic risk assessment; science or politics; scientific uncertainty and regulatory conservatism; and public perception and acceptance of risk.

Chapters 4–7 assess the toxicity of pesticides to aquatic organisms (by Nimo, Coppage, Pickering and Hansen of EPA), the impact of pesticides on ground water contamination (by Carsel and Smith of EPA) and the impact of pesticides on bird populations (by R. J. Hall of Fish and Wildlife Service). To quote Nimo et al., "while ridding the world of weeds, weevils and webworms/Be careful of fins, fur, and feathers." These chapters are primarily facts and figures on the use and effects of pesticides on fish, water and birds, and are not controversial in nature.

J. E. Davies and R. Doon in chapter 7 review the human health effects of pesticides and discuss acute pesticide poisoning, including suicides; cancer risk; residues; resistance; and disposal. The beneficial aspects of pesticides in relation to public health are neglected. Rosen and Grech present the evaluation and impact of analytical chemistry of pesticides. This chapter is a straightforward discussion of the various assay methods, from bioassay to gas chromatography to mass spectrometry.

Virgil H. Freed of Oregon State University, in chapter 9, covers the global use of pesticides and concerns. Freed points out that despite the continuing and spreading controversy over the use of pesticides, the use of such chemicals has increased annually by 4–5% on a global basis since the publication of *Silent Spring.* Most of the pesticides are used by developed nations. He mentions a study in which pesticide poisoning was examined in a number of countries. He estimates a rate of 2.9–4.8 per 100,000 persons, with a mortality rate of 5.5%. This comes to 0.16–0.26 persons per 100,000. If this figure is compared to the world wide morbidity and mortality for malaria, I believe most developing nations would consider the benefit far greater than the risk.

G. K. Kohn presents the other side of the coin in chapter 10, agriculture, pesticides and the American chemical industry. He discusses the demographic nature of American agriculture; the conflicting values; pesticides produced before and after *Silent Spring*; technology and farm income; special problems of the Third World and use of agrochemicals; and ends with a reassessment of *Silent Spring.* He notes that his rereading *Silent Spring* in no way altered his original assessment that the volume is important and would affect the publics' attitude relative to the use of pesticides and their impact on the environment.

David Pimentel of Cornell University, in chapter 11 questions, "is *Silent Spring* behind us?". He starts with, "Fewer pesticide problems during the past two decades" and then follows with, "Increased pesticide problems during the past two decades." Basically he indicates that the amount of chlorinated insecticide residues in the environment has declined since most of the chlorinated insecticides have been banned. However, pesticide production has increased, and that some of the OP pesticides may present a greater human risk. He then goes on to discussing poisonings in humans, animals and bees. His figures on pesticide effects on crops seem to be at odds with Kohn's comments. Pimentel estimates a negative impact on crops of about $70 million annually. Kohn states that the additional wealth created by the technology to be $9,125,000,000. Pimentel states that 37% of all crops is lost annually to pests in spite of the combined use of pesticidal and non chemical controls. If he is correct, what would it have been without the use of agrochemical technology? He concludes that pesticides will continue to be effective pest controls but the challenge now is to find ways to use them judiciously to avoid many of the environmental hazards and human poisonings that exist today.

Marco et al. conclude the volume with an overview of the symposium. They point out that *Silent Spring* led society to evaluate the new technologies in terms of risk versus benefits. Whereas lower levels of pesticides can now be detected, the true significance of these small amounts of pesticide residues is often quite uncertain. Toxicity evaluation is a complex process with great uncertainties, and it does not provide answers that are nearly as precise as the analytical techniques. The diverse opinions and opposing views between manufacturer-user and environmentalist are clearly seen in the chapters of this book. There are fewer farmers and less labor available, yet more mouths to feed, therefore there seems no likelihood of completely eliminating chemical controls in the near future. Rachel Carson was right in many respects, and in a fewer respects she was wrong. Nature, not just humans, generates its share of carcinogens and other poisons. Nature and humans both use chemicals to their own advantage. The human life span is increasing and birds still sing. What Rachel Carson accomplished was to set in motion a philosophy of using all tools in controlling pests, not relying exclusively on chemicals.

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91(3), 1989, p. 496

# ENDANGERED SPECIES

On January 6, 1989, the U.S. Fish and Wildlife Service published an extensive 'notice of review' on United States animal species including insects believed to be candidates for protection under provisions of the U.S. Endangered Species Act, to be extinct, or to be previously considered names that are now known to be taxonomically invalid or to represent taxa now thought to be in no danger of extinction. The Service is seeking further information on these candidates or about other species that might be considered.

General comments or comments on species from more than one Service Region should be addressed to the Director, U.S. Fish and Wildlife Service (FWE-SE), Washington, D.C. 20240. Specific comments on one or more species from a specific Region should be addressed to the appropriate Regional Director listed below. Copies of the notice may also be obtained from these addresses.

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U.S. Fish and Wildlife Service
Lloyd 500 Building, Suite 1692
500 NE Multnomah Street
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U.S. Fish and Wildlife Service
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# PROCEEDINGS
of the
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# HOMOLOGIES IN WING VENATION OF PRIMITIVE DIPTERA AND MECOPTERA

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*Abstract.*—On the basis of evidence from tracheation of wing veins, distribution of macrotrichia on veins, corrugation of the wing, and comparison of wings of Diptera to those of Mecoptera, the media is four-branched and the anterior cubitus is unbranched.

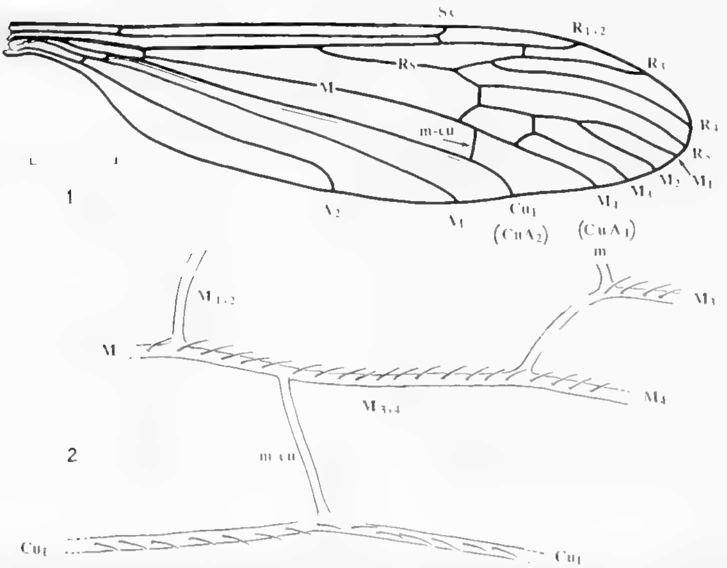
*Key Words:* wing venation, Tipulidae, Tanyderidae, Mecoptera

Dipterists are concerned with the interpretation of wing venation because they use venational consistencies and differences for recognition of taxa at all levels. Accordingly, it is awkward that conflicting views of venational homology are currently in use. In this paper, support is offered for one of those interpretations.

J. H. Comstock and J. G. Needham produced the most widely accepted system of nomenclature and homologies of wing veins of insects (Comstock 1918). Familiar to most entomologists, it need not be reviewed in detail here. In diagramming the hypothetical primitive or generalized insect wing, Comstock and Needham noted that alternating veins are elevated or convex (+), or depressed, concave (−) with respect to the plane of the wing. This corrugation, or fluting, had been pointed out earlier by Adolf (1879) and Redtenbacher (1886): the costa is +, the subcosta strongly −, anterior branch of the radius strongly +, the sector (Rs) and its branches −, anterior media + (but absent in extant orders of insects), posterior media and its branches −, anterior cubitus +, posterior cubitus −, and so on. K. G. A. Hamilton (1971: 429) noted that much of the fluting seen in wings of Paleoptera is reduced in wings of Neoptera, except in the costal area (C, Sc and $R_1$) and along the cubitus. Nevertheless, the relative elevation and depression of veins can in most cases be readily determined.

The problem with which I am concerned involves the branching of the posterior media (M) and the anterior cubitus ($Cu_1$). Comstock and Needham determined that vein M primitively was dichotomously four-branched, $M_1$, $M_2$, $M_3$ and $M_4$, all concave, reaching the wing margin. They believed that Cu was primitively two-branched rather near its base, with the anterior cubitus ($Cu_1$) being strongly convex and the posterior branch ($Cu_2$) concave. Vein $M_{3+4}$ or $M_4$ is, in their system, connected to $Cu_1$ by the m-cu cross-vein. The anterior cubitus may itself be divided into $Cu_{1a}$ and $Cu_{1b}$ (see Snodgrass 1935: 216).

A problem arose for Comstock and Needham with the observation that what appeared to be the posterior branch of M was moderately to strongly convex in Diptera. Since all branches of M were supposed to be concave, they initially said that this vein is either an anterior branch of the anterior cubitus ($Cu_{1a}$) or $Cu_{1a} + M_4$. Their eventual conclusion, however, was that in Diptera the media has only three branches and that this convex vein is a branch of the cubitus; that is, $M_4$ is always absent in wings of Diptera.



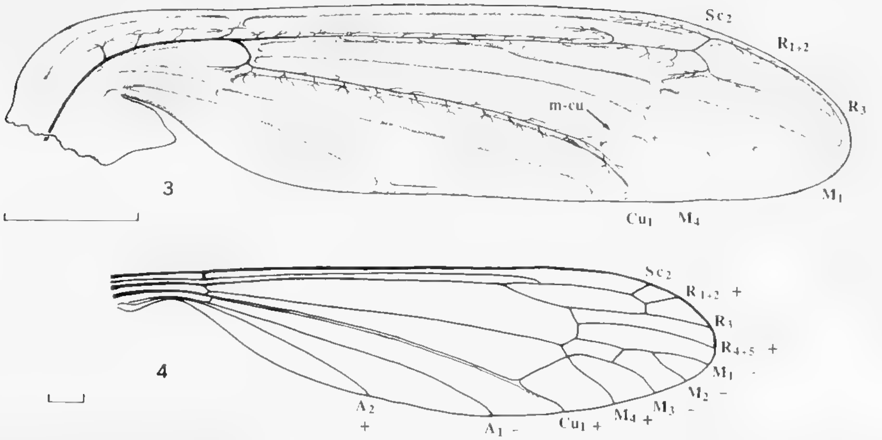
Figs. 1–2. *Pseudolimnophila inornata* (Osten Sacken). 1. Wing with venation labelled according to the Alexander-Tillyard system, with branches of M and Cu also labelled (in parentheses) according to the Comstock-Needham system. 2. Portion of venation showing distribution of macrotrichia on certain veins. Scale line = 1 mm.

This interpretation was challenged only eight years later, by R. J. Tillyard (1926), who declared that M is four-branched in flies and that $Cu_1$ is unbranched. Almost simultaneously, C. P. Alexander had reached the same conclusion, based on his study of Tipulidae and other primitive Diptera (e.g., Tanyderidae). A student of Comstock at Cornell University and at first a follower of the Comstock system (from 1919 to 1925), Alexander became convinced that the media has in Tipulidae four branches, as in the hypothetical, generalized pattern, and that what he had been calling the "anterior deflection of $Cu_1$" in crane flies was really the m-cu cross-vein.

The Alexander-Tillyard interpretation has also been widely accepted, perhaps in part because it holds that M in primitive Diptera (that is, Diptera in which the venation is not greatly reduced or modified) has the form that Comstock and Needham claimed for primitive insects generally. This view was followed, for example, by D. H. Colless and D. K. McAlpine (1970) in "The Insects of Australia." In contrast, the "Manual of Nearctic Diptera" (J. F. McAlpine et al. 1981) adopted the Comstock-Needham interpretation. Figure 1 illustrates these conflicting interpretations of M and $Cu_1$ in the wing of a crane fly.

The problem is basically this, I think: Is the vein (labelled m-cu in Fig. 1) connecting what appears to be the posterior branch of M with $Cu_1$ in fact a cross-vein, or is it the basal part of a branch of $Cu_1$? What kinds of evidence can be obtained to support one interpretation or the other?

Some similar problems have been solved by examination of tracheal branching. In Diptera, however, the veins are already clearly established in the pupal wing (the wing sheath) before tracheae enter the wing. In crane flies of the genus *Tipula* (Fig. 3), one trachea enters the radius and branches at the arculus, one branch continuing along the radius and through $R_1$ to the stigmal area, the other proceeding along the cubitus ($Cu_1$). In several pupae of *Tipula trivittata* Say examined (and in a few of other species), the cubital trachea did not give off any branch into the vein in question (which I call m-cu). In some individuals, perhaps preserved too soon, the trachea stopped be-

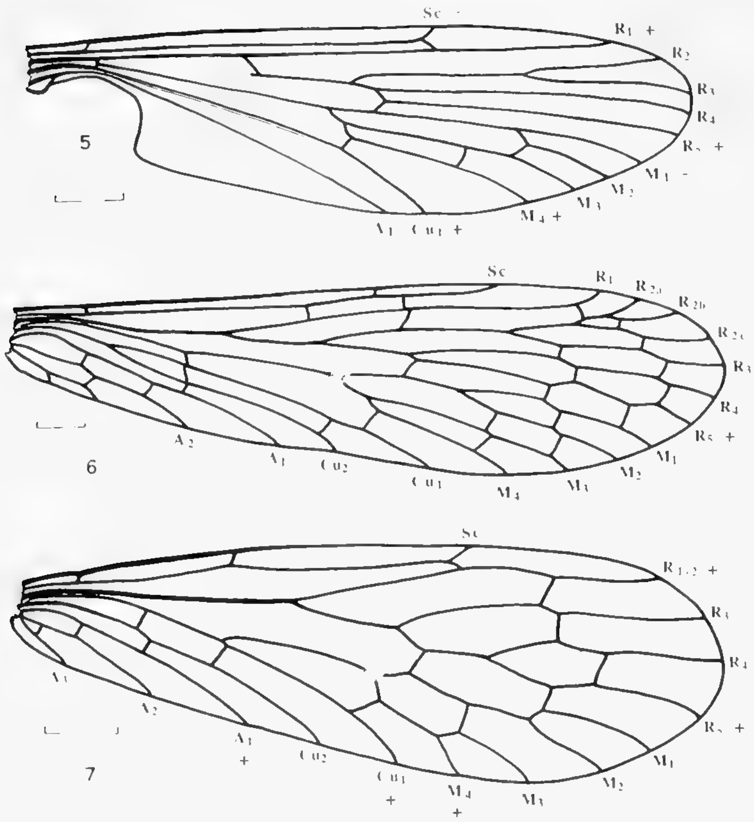


Figs. 3–4. *Tipula trivittata* Say. 3. Pupal wing (wing sheath) showing complete, slightly raised venation (shaded) and tracheal branches chiefly in $R_1$ and $Cu_1$. 4. Wing, indicating the convexity (+) or concavity (−) of certain veins. Scale lines = 1 mm.

fore reaching m-cu; in others, it passed m-cu without branching. In one specimen of *Tipula ignobilis* , however, a short branch entered m-cu for about one-fourth of the length of that vein. I find this evidence interesting but ambiguous.

A few morphologists and taxonomists have observed that, in various taxa, macrotrichia occur on certain longitudinal wing veins but not on cross-veins. This contrast is easily seen in Mecoptera, for example. Numerous individuals of several genera of Tipulidae (in all three subfamilies) were inspected with this in mind. While macrotrichia usually occur on both M and its branches and on $Cu_1$, although often only sparsely, they are almost never seen on m-cu. One or two machrotrichia were found on the cubital end of m-cu in a very few individuals. *Pseudolimnophila* illustrates well the contrasting presence of macrotrichia on M and $Cu_1$ and absence from m-cu (Fig. 2). But macrotrichia are absent as well from the basal, cross-vein-like portions of $M_1+_2$ and $M_3$, so this evidence may not be very convincing.

Homology of veins from one order to another has been determined largely by the previously mentioned corrugation, or fluting. As a general observation, two main longitudinal veins—$R_1$ and $Cu_1$—are ordinarily strongly convex in virtually all neopterous orders of insects. Such primitive flies as *Tipula* (Tipulidae) and *Protoplasa* Tanyderidae) show this condition (Figs. 4, 5). In both, a strongly concave, darkened line closely paralleling the convex $Cu_1$ but not reaching the wing margin has been interpreted as $Cu_2$ or the cubital fold, lying in the cubital furrow. Also in both, the vein that I suppose is $M_4$ is clearly convex, while m-cu is much less so and may be neither + nor −. But I cannot accept the view of Comstock and Needham that the convexity of "$M_4$" must be interpreted as this vein's being a branch of $Cu_1$. My reason is this: In all crane flies and tanyderids examined, vein $R_5$ or the combined $R_{4+5}$ is moderately to strongly convex, while the expectation is that it should be concave. Comstock and Needham, who held that the branches of the radial sector are concave, apparently took no notice of this inconsistency. W. Hennig (1969: 311,376) did, and suggested that the apparent $R_5$ could include a remnant of the convex anterior media. However, it is generally accepted, I think, that the anterior media is absent in all modern orders of insects. My interpretation of the convexity of both $R_5$ and $M_4$ is that there is a structural "need" for corrugation to give some relative rigidity and strength to the respective parts



Figs. 5–7. Wing venation, showing the convexity (+) or concavity (−) of certain veins. 5. *Protoplasa fitchii* (Osten Sacken) (Diptera:Tanyderidae). 6. *Panorpa communis* Linnaeus (Mecoptera:Panorpidae). 7. *Nannochorista neotropica* Navás (Mecoptera:Nannochoristidae). Scale lines = 1 mm.

of the wing (which are otherwise rather plane). I have no idea whether this is so; but the point is that a convex $M_4$ is no more remarkable than a convex $R_5$, and no less to be expected.

Occasionally, in local populations, one finds numerous individuals that have the branches of M variously dislocated (Byers 1961). Such aberrations appear to have a genetic basis (cf. Laven 1957). While the apparent $M_4$ is involved in these dislocations, although less so than $M_{1-3}$, and even m-cu may be affected, the anterior cubitus is not. This suggests that there are, to some extent, different factors influencing the development of M and $Cu_1$.

Finally, there is the evidence from comparative anatomy, which is more convincing to me than any of the evidence already cited. A survey of the orders of insects to determine the most likely origin of the Diptera leads us quickly to the Mecoptera. This order, the fossil record of which goes back to the lower Permian, displays the combination of characters most closely resembling that found in primitive Diptera—characters of general body structure, external genitalia of both sexes, antennae, mouthparts and wing venation. Accordingly, we may gain from examining the branching of the media and cubitus in Mecoptera some understanding of equivalent venation in Diptera.

Comstock and Needham thought that the venation in *Panorpa* (Fig. 6), a common genus of Mecoptera, agreed with their generalized plan, that is, Rs with four branches, M with four and Cu separated basally into $Cu_1$ and $Cu_2$, but $Cu_1$ with no further branching. In the medial field, the venation of *Panorpa* is strikingly like that of the tanyderid *Protoplasa* (compare Figs. 6 and 5), with the same convexity and concavity of corresponding veins. $Cu_2$ in Tanyderidae, as in Tipulidae, is only weakly developed as a dark line in the cubital furrow behind $Cu_1$.

Among the Mecoptera, *Nannochorista* (Fig. 7) is most like the Diptera; the head and mouthparts are not elongated as in most Mecoptera, the mandibles are reduced in the adult, and, in wing venation, M is fused basally with $Cu_1$. In this genus, as in Mecoptera generally, the anterior cubitus is unbranched. Moreover, in all Mecoptera the veins $R_5$ and $M_4$ are both distinctly convex, as in the primitive Diptera.

From the evidence presented, I conclude that in the Tipulidae (probably the most primitive family of extant Diptera) and in the Tanyderidae (which I consider also very primitive flies, although their phylogenetic position is still disputed) the media (M) typically has a dichotomous division, each branch again dividing dichotomously, hence four terminal branches. Further, I conclude that the anterior cubitus ($Cu_1$) in primitive Diptera, at least, is *not* branched.

There is great variation in the branching and the basal fusion of veins in the order Diptera. I have not studied this in detail. Nevertheless, I find the interpretation of venation based on the Tipulidae and Tanyderidae, and compared to that of the Mecoptera, as reasonable as any other for all Diptera. An unbranched $Cu_1$ could be thought of as one more character linking Mecoptera and Diptera (as Antliophora of Hennig, or Mecopterida of Boudreaux) and differentiating this group (which also includes the Siphonaptera) from the Amphiesmenoptera, or Trichopterida.

## ACKNOWLEDGMENTS

I thank Mr. Bryan N. Danforth for his help in rearing pupae of *Tipula* and preparing their wings for study and in verifying the patterns of corrugation of veins in various genera. Charles D. Michener and Fenja Brodo read an early version of this paper and made useful suggestions.

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# HOST SPECIFICITY STUDIES OF *STOLAS FUSCATA* (KLUG) (COLEOPTERA:CHRYSOMELIDAE) FOR THE BIOLOGICAL CONTROL OF *BACCHARIS SALICIFOLIA* (R. & P.) PERS. (ASTERACEAE)

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*Abstract.*—The leaf feeder *Stolas* (*Anacassis*) *fuscata* (Klug), from Argentina, was studied in quarantine as a potential biological control candidate of seepwillow, *Baccharis salicifolia* (R.&P.) Pers. in the United States. No-choice tests were conducted with first-instar larvae on 34 plant species in 7 tribes of Asteraceae and 3 additional families. Pupation occurred primarily on *B. salicifolia* and to a lesser degree on *Gymnosperma glutinosum* (Spreng.) Less. and *Aster subulatus* Michx. No-choice tests were also conducted with adults on 23 plant species representing 5 tribes and 12 genera of Asteraceae. Leaf consumption and longevity were greatest on *B. salicifolia* and *A. subulatus,* and oviposition occurred only on these species. *Stolas fuscata* apparently has a high degree of host specificity. This insect does not attack any economically important plant, and the risk of it feeding on any species other than *B. salicifolia* is small.

*Key Words:* Insecta, Coleoptera, Chrysomelidae, *Stolas,* Asteraceae, *Baccharis,* seepwillow, host specificity, biological control

Seepwillow, *Baccharis salicifolia* (R.&P.) Pers. (formerly = *glutinosa* Pers.) (Asteraceae) is an undesirable woody phreatophyte, 2 to 3 m in height, and has few, if any, economic benefits. This shrub contributes little to stream bank stability. Dense thickets of seepwillow impede water flow and contribute to channel migration, overflow and increased sedimentation (Horton 1959, Parker 1972). Seepwillow has little or no value to wildlife except for the cover it provides and is not listed as a food source by Martin et al. (1951) for any wildlife species in the United States. No birds are closely associated with this shrub (Engel-Wilson and Ohmart 1978, Anderson and Ohmart 1984).

*Stolas* (*Anacassis* ) *fuscata* (Klug) is a potential biological control agent for seepwillow. This beetle, a leaf feeder in both larval and adult stages, occurs only in Argentina, Brazil, Paraguay (Blackwelder 1946) and Uruguay (Guido et al. 1956). Originally described in the genus *Cassida, fuscata* was later placed in *Anacassis* by Spaeth (1913). Most recently *Anacassis* has been recognized as a subgenus of the large neotropical genus *Stolas* (Hincks 1952). This status is maintained in Seeno and Wilcox (1982) and followed in the present paper. Buzzi (1975) and McFadyen (1987), working in South America, continue to recognize *Anacassis* as a valid genus separate from *Stolas.*

I conducted host specificity tests on *S. fuscata* from Argentina as part of a project to study the biological control of seepwillow. Tests by McFadyen (1987) indicated that both *Stolas fuscata fuscata* from Brazil and *S. fuscata unicolor* (Burmeister) from Argentina feed only on 3 species of *Baccharis* and the related *Baccharidastium triplenerve* (Lessing) Cabrera.

The populations of *S. fuscata* used in these tests are probably identical to *S. fuscata unicolor* in Argentina and very similar to *S. fuscata fuscata* in Brazil. The male and female genitalia of both subspecies were compared by H. Cordo (pers. comm.). He found no consistent differences in structure. My specimens were identified as *S. fuscata* by both Z. Buzzi (pers. comm.) and R. E. White (pers. comm.), but neither identified a subspecies. Possible differences between subspecies in host feeding were reported by McFadyen (1987). In 1979 several thousand adults of *S. Fuscata fuscata* were released in Queensland, Australia, for the biological control of *B. halimifolia*. They apparently fed on the plant but did not become established in the field (McFadyen 1987). *Stolas fuscata unicolor* from Argentina was also brought into Queensland but did not survive in quarantine. The subspecies name is not used in this manuscript for lack of confirmation of its validity. Although physiological differences may exist between the populations, morphological differences are not sufficiently unique to identify subspecies.

## MATERIALS AND METHODS

Larvae and adults of *S. fuscata* were collected on *Baccharis salicifolia* by H. Cordo near Arroyito, Neuquen; Realico, La Pampa; San Rafael, Mendoza; and Pedro Luro, Buenos Aires, Argentina, during the months of February and March from 1985 to 1987 and air-freighted to the Insect Quarantine Facility, USDA-ARS, Temple, Texas. A colony of this insect was maintained in quarantine on excised leaves of potted *B. salicifolia* or leaves periodically collected in the field near Laredo, Texas.

All experiments were in the quarantine facility at Temple, Texas. The room was held at temperatures of 22 to 26° C, relative humidity of 40 to 60% and a 12:12 h L:D photoperiod under artificial light. Leaf consumption was determined by placing a 1 mm plastic grid over the leaf and counting the squares or with a Li-Cor Model Li 3000 leaf area meter before and after feeding. Because an entire experiment could not be done at the same time, there was a control treatment of seepwillow each time any plant was tested. Plants used in the tests were collected in Texas and held out-of-doors except for *Baccharis pilularis* DC., which was collected in California; those plants selected were species closely related to seepwillow or economically important. Plants were allowed to flower when possible, and voucher specimens were deposited in the permanent collection of the Grassland, Soil and Water Research Laboratory, Temple, Texas. Insect specimens were deposited in the National Museum of Natural History, Washington, DC.

Larva host tests.—No-choice tests were conducted by holding a single unfed, 0- to 48-hour old larva in a small (9.0 cm diam.) petri dish on freshly excised leaves of a selected plant species until death or pupation occurred. Leaves were replaced every second or third day. The amount of leaf consumed, stage of development and number of days survived were recorded. A replication consisted of 10 larvae per plant species. Each of the 34 plant species was replicated at least 3 times.

Adult host tests.—In the first of two adult no-choice tests, a single unsexed, unfed, 3- to 5-day-old adult was held in a small petri dish on freshly excised leaves of each test plant. Leaves were replaced every second or third day, and the amount of leaf consumed was recorded until death occurred. A replication consisted of 1 adult per plant species. Each of the 15 plant species was replicated 10 times.

The second adult no-choice test was similar except that 15, 2- to 6-day-old adults were held on each plant species in a large

Table 1. Average feeding and longevity of larvae of *S. fuscata* on leaves of various plants.

| Plant Species | No. of Larvae | Leaf Consumption (cm$^2$)[a] | Longevity Time (days)[a] |
|---|---|---|---|
| ASTERACEAE | | | |
| Astereae | | | |
| *Baccharis salicifolia* (R. & P.) Pers. | 110 | 52.6 ± 12.4 | 16.3 ± 2.3 |
| *Aster novae-angliae* L. | 30 | 0.1 ± 0.1 | 4.0 ± 0.3 |
| *A. subulatus* Michx. | 40 | 10.7 ± 4.2 | 9.0 ± 2.4 |
| *A.* sp. (form Michaelmas) | 30 | 0 | 4.0 ± 0.9 |
| *Baccharis bigelovii* Gray | 40 | 0.6 ± 0.7 | 5.3 ± 2.5 |
| *B. brachyphylla* Gray | 40 | 0 | 3.3 ± 1.0 |
| *B. halimifolia* L. | 40 | 0.6 ± 0.4 | 5.5 ± 2.0 |
| *B. neglecta* Britt. | 40 | 5.5 ± 8.8 | 7.1 ± 2.4 |
| *B. pilularis* DC. | 30 | 0.3 ± 0.2 | 5.3 ± 1.9 |
| *B. pteronioides* DC. | 30 | 0.1 ± 0.1 | 3.4 ± 0.6 |
| *B. sarothroides* Gray | 30 | 0 | 3.2 ± 0.7 |
| *Chrysothamnus nauseosus* (Pall.) Britt. | 30 | 0.1 ± 0.1 | 4.2 ± 1.4 |
| *Ericameria austrotexana* M. C. Johnst. | 30 | 0 | 3.7 ± 0.4 |
| *Grindelia lanceolata* Nutt. | 30 | 2.4 ± 3.3 | 7.1 ± 4.2 |
| *Gutierrezia microcephala* (DC.) Gray | 30 | 0.2 ± 0.4 | 5.2 ± 3.1 |
| *Gymnosperma glutinosum* (Spreng.) Less. | 50 | 0.4 ± 15.9 | 8.9 ± 7.5 |
| *Haplopappus tenuisectus* (Greene) Blake | 30 | 0 | 3.4 ± 1.3 |
| *Isocoma coronopifolia* (Gray) Greene | 30 | 0 | 3.9 ± 0.5 |
| *Solidago altissima* L. | 30 | 0.5 ± 0.9 | 4.3 ± 1.6 |
| Eupatorieae | | | |
| *Brickellia laciniata* Gray | 30 | 0.1 ± 0.1 | 2.4 ± 2.0 |
| Heliantheae | | | |
| *Helianthus annuus* L. | 40 | 0.1 ± 0.1 | 2.9 ± 0.4 |
| *Rudbeckia hirta* L. (form "gloriosa") | 30 | 0 | 2.2 ± 0.2 |
| *Viguiera dentata* (Cav.) Spreng. | 30 | 0 | 3.5 ± 0.6 |
| *Zinnia acerosa* (DC.) Gray | 30 | 0.1 ± 0.1 | 3.7 ± 0.5 |
| Helenieae | | | |
| *Callistephus chinensis* (L) Nees | 30 | 0.2 ± 0.4 | 2.3 ± 2.2 |
| *Gaillardia pulchella* Foug. (form "grandiflora") | 40 | 0 | 3.2 ± 0.7 |
| *Tagetes patula* L. | 40 | 0 | 3.1 ± 0.7 |
| Anthemideae | | | |
| *Artemisia filifolia* Torr. | 30 | 0 | 3.0 ± 0.9 |
| *Chrysanthemum cinerariifolium* Vis. | 30 | 0 | 3.2 ± 0.2 |
| *C. morifolium* Ramat. | 30 | 0.2 ± 0.3 | 2.6 ± 0.5 |
| Cynareae | | | |
| *Carduus macrocephalus* Desfontaines | 30 | 0 | 2.9 ± 0.7 |
| Cichorieae | | | |
| *Lactuca sativa* L. | 30 | 0 | 3.0 ± 0.4 |
| ASCLEPIADACEAE | | | |
| *Asclepias viridis* Walt. | 30 | 0 | 2.7 ± 1.2 |
| GRAMINAE | | | |
| *Zea mays* L. | 30 | 0 | 2.7 ± 0.3 |

[a] Mean ± standard deviation.

petri dish (14.1 cm diam). Leaf consumption, survival time, the number of eggs laid, and percent hatched were recorded. Each of the 10 plant species was replicated 3 times except for *Isocoma wrightii* (Gray) Rydb. which was replicated twice and seepwillow which was replicated 5 times. All adults were dissected after death to determine sex.

Table 2. Percentage of larvae of *S. fuscata* surviving on various test plants and number of days to pupation.

| Test Plant | No. of Larvae | Larval survival | | | | Days to Pupation[a] |
|---|---|---|---|---|---|---|
| | | 5th Instar | | Pupae | | |
| | | No. | % | No. | % | |
| *Baccharis salicifolia* | 110 | 89 | 80.9 | 83 | 75.5 | 19.1 ± 3.2 |
| *Aster subulatus* | 40 | 4 | 10.0 | 2 | 5.0 | 20.3 ± 2.75 |
| *Baccharis neglecta* | 40 | 2 | 5.0 | 0 | — | 0 |
| *B. halimifolia* | 40 | 1 | 2.5 | 0 | — | 0 |
| *Callistephus chinensis* | 30 | 1 | 3.3 | 0 | — | 0 |
| *Gymnosperma glutinosum* | 50 | 8 | 16.0 | 6 | 12.0 | 27.7 ± 1.6 |

[a] Mean ± standard deviation.

## RESULTS

Larva hosts tests.—Significant feeding and survival occurred on several species in the tribe Astereae (Asteraceae) and one species, *Callistephus chinensis* (L.) Nees, in the tribe Helenieae (Table 1). More feeding occurred on seepwillow than on either *Gymnosperma glutinosum* (Spreng.) Less. or *Aster subulatus* Michx.; and only minor feeding occurred on *Baccharis neglecta* Britt. and *Gutierrezia microcephala* (DC.) Gray. Few larvae on non-host plants, including the 5 other species of *Baccharis,* survived beyond the second instar, although some larvae survived without feeding for up to 4 days.

Neonate larvae fed and developed to the fifth instar only on the plants listed in Table 2. Normal pupation occurred for 75.5% of the larvae restricted to seepwillow but only for 12.0% of the larvae on *G. glutinosum* and 5.0% of the larvae on *A. subulatus.* Larvae on other species died without pupating.

Adult host tests.—In the first adult no-choice test, feeding occurred primarily on a few plants in the tribe Astereae. Adults on seepwillow consumed over 9 times more foliage than those on *Isocoma coronopifolia* (Gray) Greene, the next most fed on plant (Table 3). Mean longevity on seepwillow was 26.1 days, but it was longer on *I. coronopifolia, G. glutinosum* and *G. microcephala.* Survival on *Antennaria fallax* Greene was nearly as long as on seepwillow although the adults apparently did not feed.

In the second adult no-choice test, significantly greater longevity, feeding and oviposition were recorded on seepwillow than on any other species in the test (Table 4). The 39 females on seepwillow lived 34.3 days longer than the 19 females on *Aster subulatus* Michx. and laid over four times the number of eggs per female. The mean percent egg hatch was 79.4% on seepwillow as compared with 32.5% on *A. subulatus.* No eggs were laid on any other species.

## DISCUSSION

*Stolas fuscata* appears to be a suitable biological control agent for seepwillow. Hosts of *S. fuscata* are limited to a few plants in the subtribe Baccharidinarum, as shown by larval and adult multiple-choice tests on 52 plant species in 25 families in both Argentina and Brazil (McFadyen 1987). My tests of larvae on 34 additional plants and adults on 23 plants in no-choice tests also indicate a high probability that if *S. fuscata* were released in the United States it would establish only on seepwillow.

The risk that *S. fuscata* might survive on the perennial shrub *G. glutinosum* is minimal. No eggs were laid, adults fed poorly and only 12.5% of the larvae pupated on *G. glutinosum.* This plant is more closely related to the genus *Gutierrezia* than to *Baccharis* and has few recorded benefits (Martinez 1959).

Eggs were laid by *S. fuscata* only on seepwillow and *A. subulatus.* Calculations from these tests, conducted under restrictions of

Table 3. Feeding and longevity of adults of *S. fuscata* on leaves of various plants.

| Plant Species | No. of Adults | Amount Consumed (cm$^2$)[a] | Amount Consumed/Day (cm$^2$)[a] | Longevity (days)[a] |
|---|---|---|---|---|
| ASTERACEAE | | | | |
| Astereae | | | | |
| *Baccharis salicifolia* | 10 | 95.1 ± 73.9 | 33.0 ± 19.0 | 26.1 ± 17.9 |
| *B. neglecta* Britt. | 10 | 3.2 ± 6.6 | 0.2 ± 4.0 | 17.3 ± 10.6 |
| *B. halimifolia* L. | 10 | 0.1 ± 0.2 | —[b] | 14.9 ± 12.1 |
| *B. pilularis* DC. | 10 | 1.1 ± 2.2 | 0.1 ± 1.0 | 12.8 ± 6.5 |
| *Ericameria austrotexana* M. C. Johnst. | 10 | 0 | 0 | 20.5 ± 14.5 |
| *Grindelia squarrosa* (Pursh) Dun. | 10 | 3.0 ± 7.9 | 0.1 ± 1.0 | 23.9 ± 15.9 |
| *Gutierrezia microcephala* (DC) Gray | 10 | 1.1 ± 1.2 | 0.1 ± 0.0 | 32.6 ± 17.7 |
| *Gymnosperma glutinosum* (Spreng.) Less. | 10 | 5.5 ± 10.3 | 0.1 ± 2.0 | 31.1 ± 21.1 |
| *Isocoma coronopifolia* (Gray) Greene | 10 | 10.2 ± 16.6 | 0.2 ± 0.3 | 38.2 ± 19.6 |
| *Solidago altissima* L. | 10 | 0 | —[b] | 16.5 ± 14.8 |
| Anthemideae | | | | |
| *Artemisia filifolia* Torr. | 10 | 0.1 ± 2.0 | —[b] | 16.0 ± 13.0 |
| *Chrysanthemum morifolium* Ramat. | 10 | 1.0 ± 2.0 | —[b] | 12.7 ± 12.5 |
| Cynareae | | | | |
| *Centaurea macrocephala* Pushk. | 10 | 0.3 ± 0.5 | —[b] | 19.9 ± 14.6 |
| Helenieae | | | | |
| *Gaillardia pulchella* Foug. | 10 | 0 | 0 | 17.5 ± 12.3 |
| Inuleae | | | | |
| *Antennaria fallax* Greene | 10 | 0 | 0 | 21.0 ± 16.9 |

[a] Mean ± standard deviation.

[b] Amount consumed is less than 0.01 cm/day.

the quarantine, show that a hypothetical female fed leaves of seepwillow will lay 325 eggs which will result in 99.7 first generation females (Table 5). However, one female and offspring fed only on *A. subulatus* will produce less than 1 female. This difference is the result of increased oviposition on seepwillow and high mortality of eggs and larvae on *A. subulatus*. Only 5 % of the neonate larvae on *A. subulatus* survived to the pupal stage.

Occasional feeding on *A. subulatus,* if it does occur, should not be considered detrimental because this species is an annual

Table 4. Longevity and oviposition of *S. fuscata* on various species of Astereae in no-choice tests.

| | No. of adults | Longevity[a] Male | Longevity[a] Female | Leaf Consumption per adult (cm$^2$)[a] | Eggs per Female[a] |
|---|---|---|---|---|---|
| *Baccharis salicifolia* | 75 | 56.5 ± 30.1 | 69.9 ± 38.2 | 59.4 ± 17.6 | 325.2 ± 163.6 |
| *Aster subulatus* Michx. | 45 | 44.9 ± 21.7 | 35.6 ± 22.8 | 37.7 ± 8.7 | 72.0 ± 64.8 |
| *A. ericoides* L. | 45 | 9.2 ± 5.2 | 13.4 ± 5.9 | 0.4 ± 0.4 | 0 |
| *A. novae-angliae* | 45 | 9.1 ± 3.4 | 9.5 ± 3.8 | 0.5 ± 0.5 | 0 |
| *A. praealtus* Poir. | 45 | 20.3 ± 13.0 | 29.7 ± 18.9 | 12.4 ± 3.5 | 0 |
| *A. spinosus* Benth. | 45 | 8.5 ± 1.5 | 9.1 ± 1.5 | 0.1 ± 0.1 | 0 |
| *A. texanus* Burgess | 45 | 7.6 ± 2.6 | 13.4 ± 8.6 | 0.5 ± 0.7 | 0 |
| *Ericameria laricifolia* (Gray) Shinners | 45 | 10.7 ± 6.3 | 14.8 ± 15.7 | 0.1 ± 0.1 | 0 |
| *Gymnosperma glutinosum* (Spreng.) Less. | 45 | 13.0 ± 8.3 | 9.9 ± 5.2 | 0.2 ± 0.3 | 0 |
| *Isocoma wrightii* (Gray) Rydb. | 30 | 5.7 ± 1.6 | 5.6 ± 1.2 | 0.1 ± 0.1 | 0 |

[a] Means ± standard deviation.

Table 5. Survival of *S. fuscata* when parent and offspring are fed *B. salicifolia* or *A. subulatus.*

| Stage | *B. salicifolia* | | | *A. subulatus* | | |
|---|---|---|---|---|---|---|
| | Sample size | No. entering stage | % survival | Sample size | No. entering stage | % survival |
| Egg | 39 | 325 | 79.4 | 19 | 72 | 32.5 |
| Larva | 110 | 258 | 75.5 | 40 | 23.4 | 5.0 |
| Pupa | 83 | 194.8 | — | 2 | 1.17 | — |
| No. of females (51.2%) | | 99.7 | | | 0.6 | |

native weed with no economic value. It is abundant in ditches, margins of ponds, streams, and poorly drained areas of the United States from North Carolina to California (Correll and Johnston 1979). It is widespread in Central America and is considered a weed in Australia and western Asia (Faust and Strang 1983).

There are no *Baccharis* species listed in the Federal Register of 1986 as being threatened or endangered (Anon. 1986).

Biological control of seepwillow offers a relatively inexpensive, environmentally-compatible alternative to both mechanical and chemical control. A comparison of the climate where *S. fuscata* occurs in Argentina with the climate associated with the geographical distribution of seepwillow in North America suggests that the insect may adapt to the arid southwestern United States and probably move into northern Mexico (Walter et al. 1975). The release of *S. fuscata* would represent one of the first deliberate attempts to control a native plant with an exotic insect in the continental United States. The expected result is a reduction in the density of this plant but not its elimination (Johnson 1984, Harris 1986).

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# FINAL INSTAR LARVA OF THE EMBOLEMID WASP, *AMPULICOMORPHA CONFUSA* (HYMENOPTERA)

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*Abstract.*—The development of the embolemid wasp *Ampulicomorpha confusa* is similar to that of dryinids. The embolemid larva is enclosed in a sac bulging from its homopteran host, and the sac is of larval origin. The final instar is described, and notes are provided on the occurrence of embolemids in Texas.

*Key Words:* Embolemidae, Achilidae, larva

Recent works on the Chrysidoidea, culminating in that of Carpenter (1986), have greatly clarified relationships within this superfamily. The resulting classification provides a convenient framework for the observations recorded here on the Embolemidae. Members of this family are rarely collected, and what little is known about their biology is limited to the observations of Bridwell (1937, 1958). Buergis (1987) provides a recent summary, including morphological observations for the family as a whole and collection records for European species.

In 1982, I reared a single male of *Ampulicomorpha confusa* Ashmead. Unfortunately, additional attempts to rear this species have failed. The results presented here add few new details to the observations of Bridwell (1958), but do clarify some aspects of the biology of *A. confusa.*

## Materials and Methods

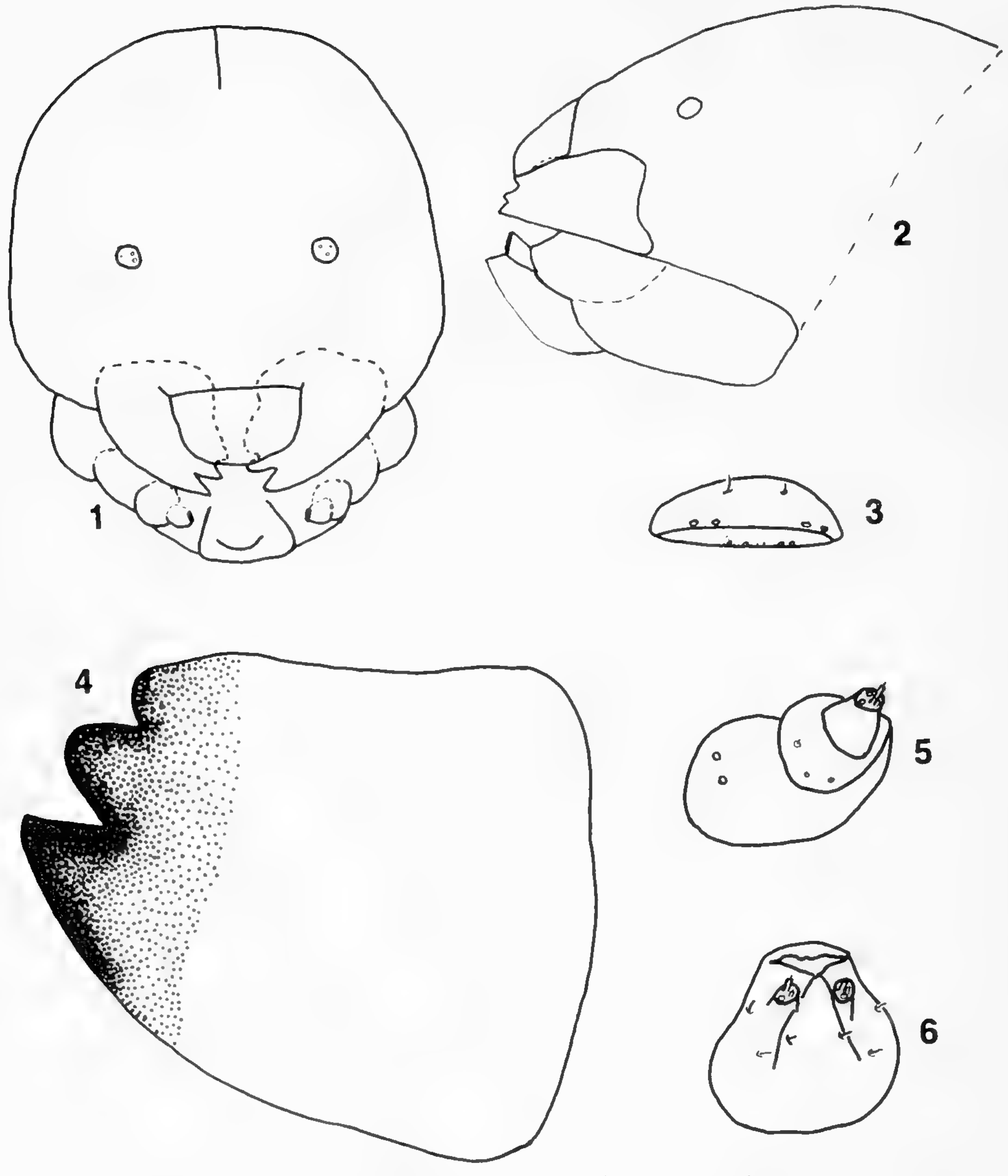
On February 13, 1982, I collected several nymphs of *Epiptera floridae* (Walker) (Homoptera, Achilidae) in San Jacinto County, Texas. The habitat was identical to that described by Bridwell (1958): beneath loose bark of rotting conifer logs. Two of these nymphs had sacs bulging laterally between the second and third abdominal segments. These two nymphs were placed in a separate vial with pieces of bark and kept under observation for the next six weeks.

Members of two other wasp families (Rhopalosomatidae and Dryinidae) develop in sacs on their exopterygote hosts, and representatives of these were used for comparison in the description of the embolemid larva and its sac. Four crickets (Gryllidae) parasitized by rhopalosomatids were collected in College Station, Texas, in September of 1987 and 1988. Determined and undetermined dryinids were also examined: determined material consisted of host remains of reared specimens in the genera *Anteon* and *Pseudogonatopus*; undetermined material included approximately 2 dozen homopteran hosts containing dryinid larvae in sacs bulging from their bodies. The latter were from numerous localities and were all preserved in 70% ethanol.

All hosts and parasitoids were identified by the author, and voucher specimens have been deposited in the Texas A&M University Collection as TAMU voucher #228.

## Results and Discussion

The embolemid sacs bulging from the nymphal achilids were identical in appear-



Figs. 1–6. Head and mouth parts of final instar larva of *Ampulicomorpha confusa*. 1, frontal view 100×. 2, lateral view, 100×. 3, labrum, ventral view showing part of epipharyngeal region, 160×. 4, left mandible, frontal view, 400×. 5, maxilla, ventral-lateral view, 160×. 6, labium, ventral view, 160×.

ance to those produced by the larvae of dryinids on their homopteran hosts. These sacs were in fact embolemid larval exuviae, as evidenced by the rows of spiracles along the sides of the sacs. As Carpenter (1986) has noted, Bridwell's (1958) description did not clearly address the question of whether the tissue composing the sacs was of host or parasitoid origin. The observations here confirm the parasitoid origin of the sac.

As in most dryinids I have examined, the embolemid sac is more or less transversely oriented to the body of the host as opposed to the longitudinal orientation of the sacs produced by rhopalosomatid larvae on their gryllid hosts. In addition, the posterior portion of the rhopalosomatid body is attached in anchor-like fashion while the head remains free. The rhopalosomatid larva lies stretched out along the side of its host. Dryinid and embolemid larvae have the head more completely buried in the host's body, and are doubled up in the sac (and thus cyphosomatic).

One embolemid larva emerged from its host within two weeks and spun a cocoon on the bark. The cocoon was identical to that described by Bridwell (1958). On March 22nd of the same year, a male *A. confusa* emerged from this cocoon. The remaining embolemid larva was preserved in 70% ethanol after it emerged from its host. The brief description given below is of this second larva. The body was poorly preserved and certain details are not evident.

The larva of *Ampulicomorpha* is readily distinguished from that of *Rhopalosoma* since the spinnerets of the latter are paired and palpiform. Detailed comparisons will be needed, however, before the larvae of embolemids can be distinguished from those of other chrysidoids. Evans (1987) provides a synopsis of existing data on chrysidoid larvae. The large, tridentate mandibles separate the larvae of *A. confusa* from those of known dryinids, but few of the latter have been described. Some chrysidids and bethylids also have tridentate mandibles, hence *A. confusa* larvae key to these families in couplet 50 of Evans (1987).

Chrysidoid larvae are insufficiently known to permit placement of embolemids on the basis of larval morphology alone. The developmental biology and host associations, however, clearly confirm the sister group relationship between embolemids and dryinids, as outlined by Carpenter (1986).

I have collected adults of *A. confusa* in Malaise traps from April through June in central Texas. In the same traps, I have collected male *Embolemus* from May through October. The two genera are readily distinguished on the basis of the relatively larger, more quadrate pronotum and weaker fore wing venation of *Ampulicomorpha*. The females of *Embolemus*, as far as is known, are apterous.

Description of Larva.—3.5 mm long, mostly white, mandibular teeth dark brown; body segments and head capsule distinct. Spiracles and atrium simple, without distinct peritreme, diameter of spiracle varying from 0.024 mm on abdomen to 0.036 mm on thorax. Integument largely smooth, not obviously setose or spinose. Head (Figs. 1, 2) more or less prognathous, 0.60 mm wide, 0.62 mm long (length measured dorsally between apex of labrum and posterior margin of head capsule), without evident parietal bands but with a median ecdysial line posteriorly. Antenna small, round, not protruding, bearing 3 minute sensilla. Clypeus distinct distally, but frontal-clypeal suture not visible; labral-clypeal suture below or extending anteriorad base of mandibles. Labrum (Fig. 3) dorsally with a pair of distinct setae and a group of smaller sensilla along anterior margin; epipharynx at least medially covered with minute sensilla. Mandibles large, tridentate in frontal view (Fig. 4), the teeth decreasing in length mesally. Maxillae (Fig. 5) weakly bilobate, simple, with large, protruding palpi, the latter with 4 minute sensilla; a galea was not observed. Labium (Fig. 6) with large median spinneret and a pair of distinct palpi.

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# REVIEW OF NEARCTIC *METACHELA* COQUILLETT, WITH DESCRIPTION OF A NEW SPECIES (DIPTERA: EMPIDIDAE; HEMERODROMIINAE)

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*Abstract*—The genus *Metachela* is reviewed for the Nearctic region. Generic diagnosis and new diagnoses of two previously described species, *Metachela albipes* (Walker) and *M. collusor* (Melander), are presented with discussion of intraspecific variation in male terminalia. ***Metachela convexa*** n. sp. is described. A key to Nearctic males, illustrations of male terminalia, and known distributions are provided.

*Key Words*: Diptera, Empididae, Hemerodromiinae, *Metachela*, dance flies

Aquatic dance flies of the genus *Metachela* Coquillett are small, slender, and possess strongly raptorial fore legs; wings lack an anal lobe and thus are relatively slender. The genus *Metachela*, therefore, is similar in general morphology to other Hemerodromiinae genera, the Nearctic species of which were treated by Melander (1902, 1928, 1947). The present study was facilitated by the relatively large numbers of *Metachela* specimens added to North American collections since Melander's (1947) revision. Generic diagnosis, diagnoses of two previously described species, description of a new species, known distributions, and a key to Nearctic males are provided.

*Metachela* species are uniform in general morphology and coloration, and possess few characters of taxonomic value. Male terminalia are of little use in separating the two widespread, common species, but are distinct for a newly described species. Interpretation of male terminalia follows that of Chvala (1983). The only other taxonomic tool was related to the structure and vestiture of the fore femora. Vestiture terminology follows McAlpine et al. (1981). The basic form of macrotrichia is a seta (= a hollow, articulated, epidermal outgrowth), with the following descriptive terms applied to it: hair (= long, weak seta); bristle (= long, strong seta); and setula (= short, strong seta). In addition to the various forms of macrotrichia, *Metachela* specimens possess pollinosity (= dense microtrichia) over much of the body. No reliable characters were discovered for females despite examination of several hundred, and thus only collecting data pertaining to males could be used to generate the distribution map.

The following institutions provided material upon which this work is based: American Museum of Natural History, New York (AMNH); Biosystematics Research Centre, Ottawa (Canadian National Collection) (CNC); California Academy of Sciences, San Francisco (CAS); Cornell University, Ithaca (CU); Florida State Collection of Arthropods, Gainesville (FSCA); Illinois Natural History Survey (INHS); United States National Museum of Natural History, Washington D. C. (USNM); University of California, Riverside (UCR); University of Kansas, Lawrence (SNOW); University of Minnesota, St. Paul (UMSP); Utah State

University, Logan (USU); and Washington State University (JAMES). Specimens also came from the author's collection (MAC) and the Purdue Entomological Research Collection (PERC).

## Genus *Metachela* Coquillett

*Metachela* Coquillett 1903: 253, 263. Type species: *Hemerodromia collusor* Melander (orig. des.).

Diagnosis.—The genus *Metachela* is distinguished from other genera of Hemerodromiinae by the combination of the following: relatively long, thick stylus of the antennae, absence of crossvein bm-cu, and existence of two veins (anterior one forked) arising from apex of fused cell bm + dm.

Description.—Small (body length ca. 3.5 to 4.0 mm), slender, with strongly raptorial fore legs. Nearctic species uniformly greyish black with golden pollinosity on scutum, white pollinosity elsewhere on thorax and on head. Mouthparts and palps yellowish. Legs concolorous yellow, except for darkened apical one or two tarsomeres. Fore femora and fore tibiae possess two median rows of black setulae ventrally, with those of fore femora flanked by row of light brown bristles and with group of paler setae basoventrally. Mid tibiae ventrally with short, apical row of black setulae. Body setae yellowish. Prominent setae of head including pair of long ocellars and pair of long inner verticals, with a pair of shorter, outer verticals detectable on some specimens. Prominent thoracic setae including several short setae on pronotum, pair of long notopleurals, pair of long supraalars, and pair of long scutellars apically, with very short pair immediately lateral to scutellars. Male terminalia composed of hypandrium, pair of gonocoxites that each possess apical fringe of setae and apicodorsal claw-like gonostylus, and epandrium consisting of two, broadened lobes that rest on top of gonocoxites. Aedeagus arising from complex aedeagal apodeme; relatively thick, with apex surrounded by several very small, sclerotized plates. Segments eight and nine of female abdomen forming exposed "ovipositor" that is sclerotized and terminates in pair of slender cerci.

Remarks.—Flies of the genus *Metachela* closely resemble species of *Chelifera*, but the difference in antenna stylus and stable differences in wing venation support separate generic status, a taxonomic treatment proposed by Coquillett (1903) and followed by Melander (1947). *Metachela* appears to be a very small genus; in addition to the Nearctic species treated in this paper, one species occurs in central Europe (Frey 1956). South American species placed in *Metachela* by Collin (1933) and Smith (1962) are, according to Smith (1962), not typical of the genus, differing in several respects from the type species; the taxonomic status of these species has yet to be established.

Almost nothing is known about the biology of *Metachela* species, but adults have been observed preying on adult Simuliidae (Peterson 1960). Most specimens in collections have been swept off riparian vegetation and taken in Malaise traps placed along and across streams. Collecting data reveal that adults appear by late June and continue to be taken well into September. Larval and pupal stages have not been described.

Nearctic species are either boreal or associated with western mountain streams, with only one, *M. albipes* (Walker), extending into eastern North America.

### KEY TO NEARCTIC SPECIES OF *METACHELA* COQUILLETT (MALES ONLY)

1\. Gonocoxites expanded laterally, strongly convex in dorsal view; apex of epandrial lobes turned inward as rounded process lined with black setulae (Fig. 1) ...................... *Metachela convexa*, new species

– Gonocoxites not expanded laterally, not strongly convex in dorsal view; apex of epandrial lobes without in-turned, rounded process lined with black setulae (see Figs. 4–7) ...... 2

2\. Inner surface of fore femora with long setae; length of basoventral setae of fore femora

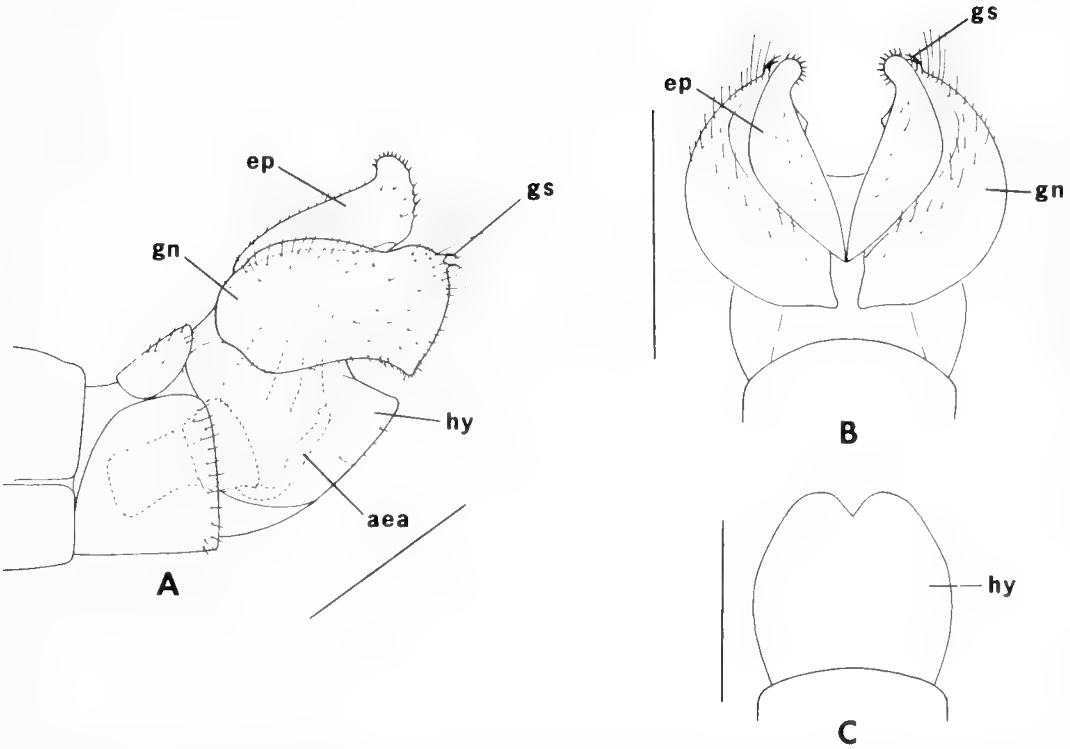


Fig. 1. *Metachela convexa* male terminalia (ep = epandrial lobe; gn = gonocoxite; gs = gonostylus; hy = hypandrium; aea = aedeagal apodeme). A – lateral view; only basal portion of aedeagal apodeme shown. B – dorsal view; hypandrium removed. C = ventral view of hypandrium. Scale: 0.5 mm.

longer than greatest width of fore femur (Fig. 2) .................. *Metachela albipes* (Walker)

Inner surface of fore femora without long setae; length of basoventral setae of fore femora subequal to greatest width of fore femur (Fig. 3) ................ *Metachela collusor* Melander

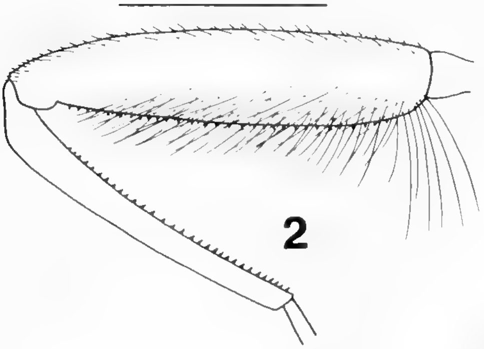
### *Metachela albipes* (Walker)

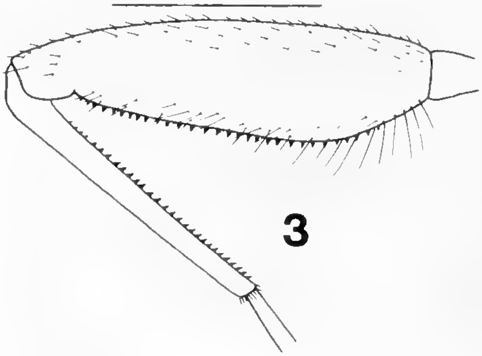
*Metachela albipes* (Walker), 1849: 505 (*Hemerodromia*).

Diagnosis.—*Male:* Body length, including terminalia, ca. 4.0 mm. Inner surface of fore femora (Fig. 2) with long setae; fore femora relatively slender, ca. 4 times longer than greatest width, with group of basoventral setae longer than greatest width of fore femora. Male terminalia as in Fig. 4; gonocoxites not expanded laterally; apical fringe of gonocoxites with longest setae ca. as long as epandrial lobes; apex of epandrial lobes smoothly rounded, without black setulae. *Female:* indistinguishable from females of other *Metachela* species.

Type material.—Lectotype male (Smith 1971: 365), Canada, St. Martin's Falls, Albany River, Hudson's Bay (G. Barnston label), deposited in British Museum (Natural History). The specimen was examined by K. V. G. Smith (June 1988), who reported (pers. comm.) it to be in "very bad condition," but "the fringe of long hairs on the inner surface of the front femur are quite easily seen." The terminalia, mounted in balsam and illustrated in Smith (1971), agree with specimens that I have seen from Canada and the United States.

Specimens examined.—164 males. Alberta: 2, Belly River, Aug.; 15, Wild Hay R. at Hwy. 40, Aug. (CNC). British Colum-





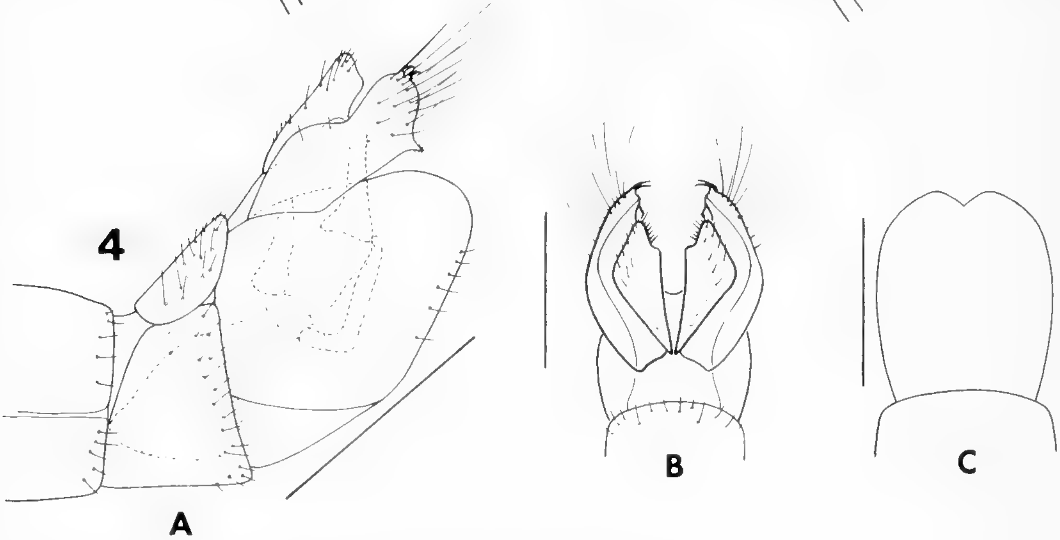
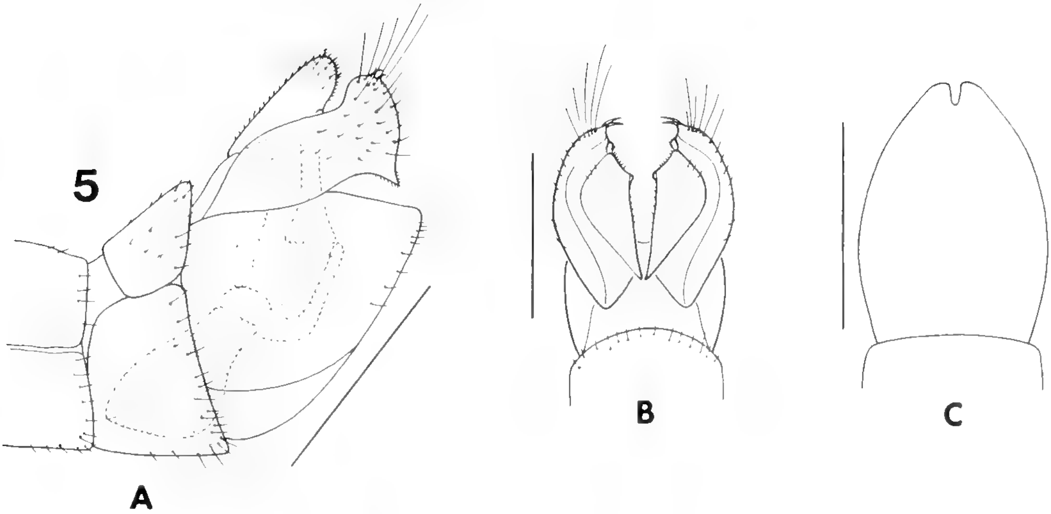


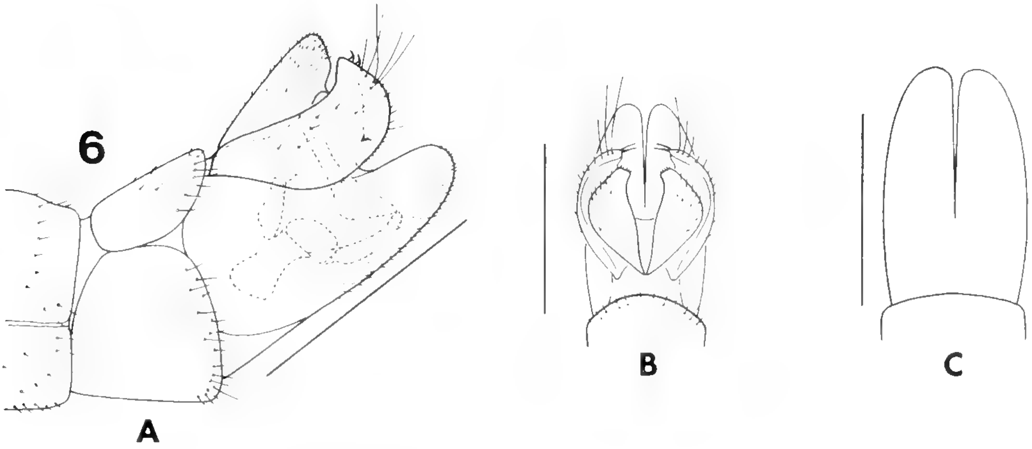
Fig. 2. *Metachela albipes* front femur, inner surface. Scale: 0.5 mm.

Fig. 3. *Metachela collusor* front femur, inner surface. Scale: 0.5 mm.

Fig. 4. *Metachela albipes* male terminalia. A = lateral view; only basal portion of aedeagal apodeme shown. B = dorsal view; hypandrium removed. C = ventral view of hypandrium. Scale: 0.5 mm.

bia: 1, Taylor Landing, Peace R., Aug. (CAS); 3, Tyree, 27 mi. E. Prince Rupert, June; 1, Lakelsch Bog nr. Terrace, June (CNC). Manitoba: 1, Mosquito Pt., Churchill R., Aug. (CNC); 4, 20 mi S. Churchill, Aug. (UMSP). Quebec: 1, Brador Bay, July; 2, Great Whale R., July; 1, Indian House L., Aug.; 4, Ft. Chino, Aug.–Sep. (CNC); 1, Brador Bay, Aug. (FSCA). California: 1, Carmel, July (AMNH); 32, Los Angeles Co., n. fork San Gabriel R., nr. Coldbrook Sta., June; 1, Modoc Co., Cedar Pass, Aug. (CAS); 4, Placer Co., Granite Flat cmpgr., Sep. (MAC); 12, Mono Co., Lower Rock Cr., Sep. (UCR); 1, Lone Pine, July; 1, Sequoia Nat. Pk., Aug. (SNOW); 1, Humboldt Co., Hydesville, Aug.; 1, Tulare Co., Camp Nelson, July; 1, Barton Flat, South Fork Camp, Sep.; 1, Los Angeles Co., s. fork Santa Ana R., Aug.; 2, Palm Springs, Nov. (USNM). Montana: 2, Glacier Nat. Pk., Swiftcurrent cmpgr., Aug. (CAS); 1, Thompson, Aug. (USNM). New Hampshire: 1, "White Mts." (USNM). Oregon: 1, Grant Co., Beech Cr. cmpgr., July; 1, Lane Co., Salt Cr. Falls cmpgr., July; 1, Wasco Co., Warm Springs Indiana Res., Beaver Cr., June (CAS); 1, Baker Co., Big Cr., Aug. (JAMES); 1, Eagle Cr., Aug.; 3, Humbug St. Pk., Aug. (USNM). Washington: 1, Clallum Co., Tumbling Rapids Rec. Area, July; 3, Grays Harbor Co., Olympic Nat. Pk., Willaby cmpgr., July;





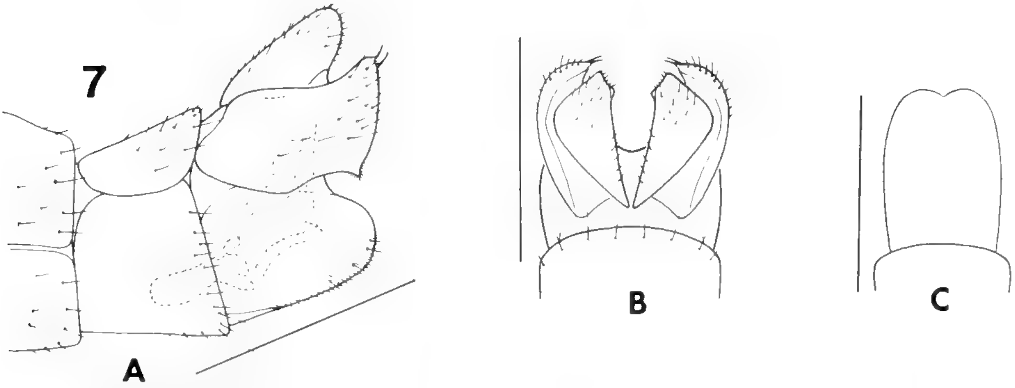


Fig. 5. *Metachela collusor* male terminalia, predominant form. A – lateral view; only basal portion of aedeagal apodeme shown. B = dorsal view; hypandrium removed. C = ventral view of hypandrium. Scale: 0.5 mm

Fig. 6. *Metachela collusor* male terminalia; digitate form. A = lateral view; only basal portion of aedeagal apodeme shown. B = dorsal view; hypandrium shown. C = ventral view of hypandrium. Scale: 0.5 mm.

Fig. 7. *Metachela collusor* male terminalia; small form. A = lateral view; only basal portion of aedegal apodeme shown. B = dorsal view; hypandrium removed. C = ventral view of hypandrium. Scale: 0.5 mm.

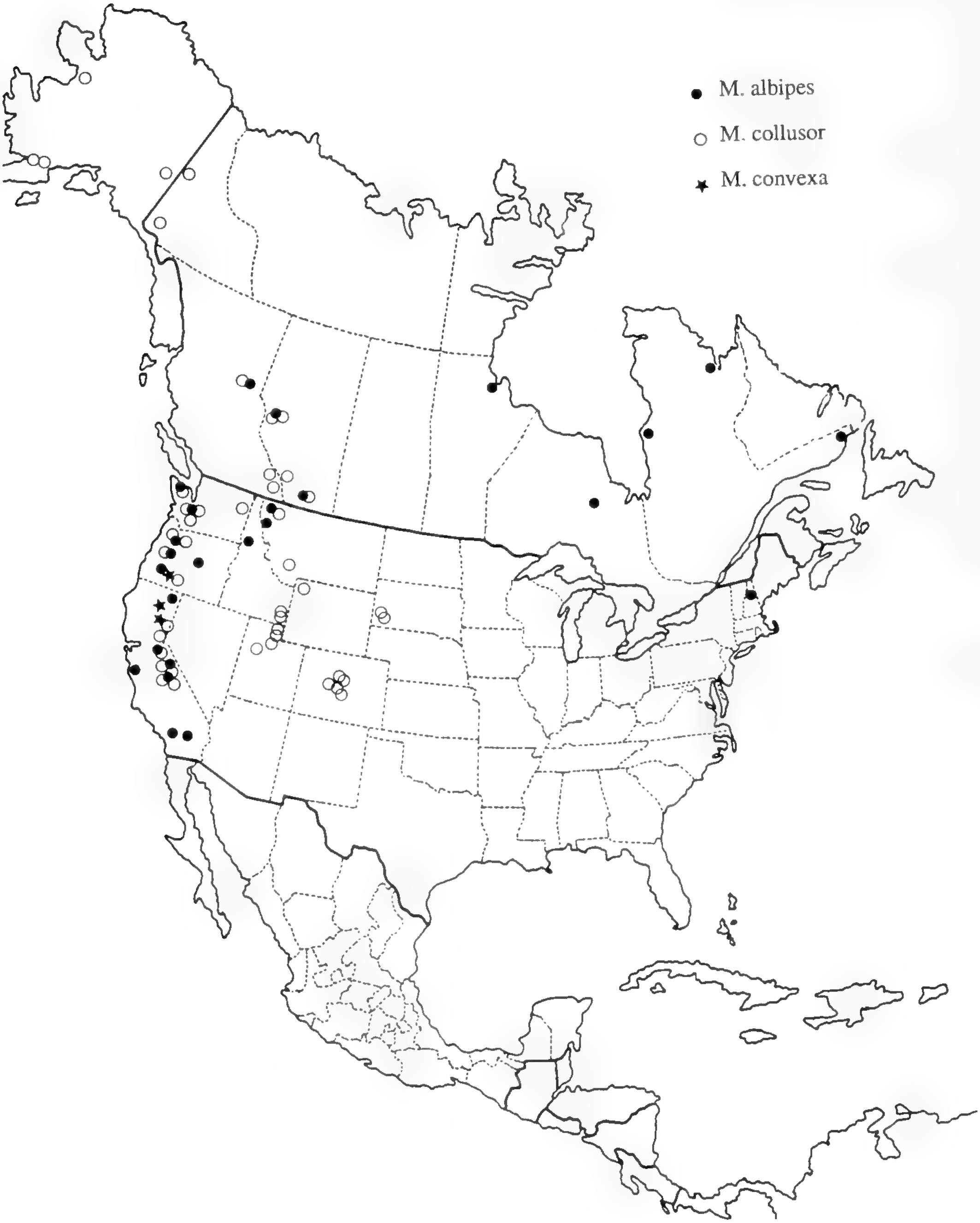


Fig. 8. Distribution of Nearctic *Metachela*.

1, Jefferson Co., Olympic Nat. Pk., July (CAS); 10, Asotin Co., Asotin Cr., Aug.; 1, Jefferson Co., Hoh R., Cottonwood cmpgr., July; 40, Lewis Co., Rainbow Falls State Pk., June–July (JAMES); 1, Yakima Co., Tieton R., 20 mi. W. Natches, Oct.;1, Yakima Co., Oak Cr. canyon, 6 mi. W. Natches, Oct. (MAC); 1, Adna, July; 1, Lilliwaup, Aug. (USNM).

Remarks.—The vast majority of *M. al-*

*bipes* males are distinguished from other Nearctic *Metachela* by the distinctive long setae on the inner surface of the fore femora and by the long setae basoventrally on the fore femora (Fig. 2). The inner setae provide the best diagnosis, although they tend to be less prominent in some southern California specimens; however, these specimens still possess the long basal setae on the fore femora and thus are distinct from *M. collusor*. Male terminalia of *M. albipes* (Fig. 4) and *M. collusor* (Figs. 5–7) possess only subtle differences, which are not taxonomically useful because they are difficult to characterize.

Five males collected in California, three from Fresno Co., Bear Cr. (1-VIII-1979) and two from Siskiyou Co., Klamath National Forest., S. of Forks of Salmon R. (22-VII-1980) (CAS), that agreed with *M. albipes* in all other respects possessed terminalia that were reduced in size, contained relatively short setae in the apical fringe of the gonocoxites, and had much more slender epandrial lobes. I consider these males as structural variants of *albipes*, based on the existence of so few specimens, the occurrence of a similar pattern of variation in *M. collusor*, and lack of additional evidence that would suggest separate taxonomic status.

*Metachela albipes* is the most widely distributed Nearctic species of *Metachela*, occurring from eastern Canada and New Hampshire to western Canada, and south along the mountains of Montana, Washington, Oregon, and California (Fig. 8).

### *Metachela collusor* (Melander)

*Metachela collusor* (Melander), 1902: 235 (*Hemerodromia*).

Diagnosis.—*Male:* Body length, including terminalia, ca. 4.0 mm. Inner surface of fore femora (Fig. 3) without long setae; fore femora relatively stout, less than 4 times longer than greatest width, with basoventral setae subequal to greatest width of fore femora in most specimens. Male terminalia as in Figs. 5–7; gonocoxites not expanded laterally; apical fringe of gonocoxites with longest setae ca. as long as epandrial lobes in most specimens; apex of epandrial lobes smoothly rounded, without black setulae. *Female:* indistinguishable from females of other *Metachela* species.

Type material.—LECTOTYPE male, labelled "Dubois, Wyo/7200 ft/ ix 6. 95" here designated from Melander's cotype series number 29180 (all in excellent condition). The lectotype and two male and three female paralectotypes are deposited in the United States Museum of Natural History (USNM).

Other specimens examined.—363 males. Alberta: 11, Banff, Aug.; 4, Wild Hay R. at Hwy. 40, June (CAS); 1, 20 mi. W. Calgary, June; 1, Jasper, July (CNC). British Columbia: 1, Mt. Fitzwilliam nr. Lucerne, Aug; 5, nr. Golden, Aug.; 10, Taylor Landing, Peace R., Aug.; 1, Kootenay Nat. Pk, Dolly Varden Cr., July (CAS). Yukon Territory: 9, 14 mi. E. Dawson, July–Aug.; 1, Swift R., Rancheria, Aug.; 2, Whitehorse, Aug. (AMNH); 1, Whitehorse, July (CNC); 2, Whitehorse, Aug. (USNM). Alaska: 20, Tok R., Glenn Hwy., Aug. (CAS); 2, Big Delta, July; 15, King Salmon, Naknek R., July; 1, Unalakleet, July (CNC). California: 55, Fresno Co., Huntington L., Rancheria Cr., Aug. (MAC, PERC); 2, Lone Pine, July (SNOW); 8, Alpine Co., Disaster Cr., July; 2, Alpine Co., Little Teton Cr., July; 1, Fresno Co., Bolsillo Cr. cmpgr., Aug.; 2, Fresno Co., Edison L., Aug.; 1, Mono Co., Leavitt Meadow, Aug.; 4, Tuolumne Co., Clark Fork R., July (CAS); 1, Sierra Nat. For., Vee Lake, Aug. (MAC). Colorado: 12, Boulder, Aug.; 1, Steamboat Springs, Aug.; 6, Chaffee Co, Garfield, Aug. (CAS); 1, Estes Park, July; 1, 3 mi. SW. Idaho Springs, July; 2, Raymond, St. Vrain Cr., Aug. (CNC); 1, Midland, Aug. (INHS); 1, Boulder Co., Boulder Cr., Sep.; 15, Estes Park, July; 1, Florissant, Aug.; 1, Rocky Mt. Nat. Pk., June; 2, N. St. Vrain Cr., Sep (USNM). Idaho: 1, Latah Co., Big Meadow Rec. area, June (JAMES); 5, Caribou Co., Kendall Cr., June–July; 1, Franklin Co., Aug. (USU). Montana: 1, Beaver

Cr., Aug.; 1, Ennis, Aug.; 1, Glacier Nat. Pk., Lake McDonald, June; 1, Glacier Nat. Pk., Logan Falls, July; 3, Glacier Nat. Pk., Second Medicine L., Aug. (USNM). Nevada: 1, Washoe Co., Verdi, June (CAS). Oregon: 4, Clackamas Co., Mt. Hood Nat. For., Tollgate cmpgr., June; 28, Klamath Co., 5 mi N. Chiloquin, June; 2, Wasco Co., Warm Springs Indiana Res., Beaver Cr., June (CAS); 1, Clack. Co., nr. Rhodendron, June (JAMES); 2, Corvallis, June; 3, Hood River, June (USNM). South Dakota: 19, Lawrence Co., Spearfish Cr., June (USNM). Utah: 9, Cache Nat. For., Wasatch Mts., July (USNM); 1, Cache Co., Logan Canyon, June; 1, Jaub Co., Mt. Nebo, July–Aug. (USU). Washington: 11, Mt. Ranier Nat.Pk., Fish Cr., Aug. (CAS); 1, Glenwood, Klickitat R., June (CNC); 3, Glenwood, Klickitat R., June (CU); 15, Asotin Co., Asotin Cr., June; 2, Mt. Ranier Nat. Pk., Tahoma R., Aug.; 1, Yakima Co., Nile, June (JAMES); 24, Glenwood, Klickitat R., June–July; 3, Husan, July; 1, Spokane, Aug. (USNM). Wyoming: 1, Yellowstone Nat. Pk., Aug. (UCR); 1, Canyon Camp, Aug.; 2, Indiana Cr., July; 4, Madison R., Riverside, Aug.; 2, W. Craigs Pass, Aug. (USNM).

Remarks.—Absence of long setae on the inner surface and existence of shorter setae basoventrally on the fore femora of males distinguish *M. collusor* from *M. albipes*. The latter trait is somewhat variable, with some *M. collusor* males possessing basoventral setae that are longer than the greatest width of the fore femora. However, the fore femora of such specimens are relatively thick (their length less than four times their greatest width) and there are no long setae on the inner surface.

*Metachela collusor* is a widespread western species, distributed from western Alaska south into the Sierra Nevada Mountains of central California and the central Rocky Mountains (Fig. 8). Variation in pigmentation of the fore coxae and in terminalia structure exists throughout the range of this species, as described below.

Variation in the pigmentation of the fore coxae of males in several series of *M. collusor* from Alaska, British Columbia, central Colorado, and Yukon Territory resulted in coloration ranging from entirely yellow to entirely dark brown. Specimens with various forms of intermediate pigmentation of the fore coxae were collected concurrently and lacked consistent differences in other characters, including details of male terminalia.

The predominant terminalia structure of *M. collusor* males is depicted in Fig. 5, but variation in size and shape of the component parts existed throughout the range. The two extreme forms of this variation (Figs. 6, 7) are firstly, a hypandrium with somewhat digitate apical processes (Fig. 6) and secondly, terminalia of substantially smaller overall size with an accompanying reduction in the aedeagal apodeme and length of setae in the gonocoxite fringe (Fig. 7).

The form of terminalia with two digitate processes at the apex of the hypandrium (Fig. 6) existed on 12 males from Naknek, Alaska (CNC), four males from Caribou County, Utah (USU), and five males from Lawrence County, South Dakota (USNM). The males from Alaska and South Dakota were part of series of concurrently collected males that included individuals with the predominant form of terminalia (Fig. 5) and a few specimens that could be placed with either the digitate form or the predominant form, depending on how they were viewed. Macerated terminalia of one of these males, which was difficult to place before dissection, revealed that only one side of the apex of the hypandrium appeared "digitate"; the other side of the hypandrium resembled the apex of the predominant form. The appearance of these two forms of *M. collusor* terminalia stems, at least in part, from the variable manner in which the hypandrium collapses on killed specimens as they dry. Another contributing factor to an appearance of distinctiveness in structure is the size of the hypandrium, with the digitate form of hypandrium tending to be smaller and more slender than the predominant form.

The type of terminalia of an overall much smaller size (Fig. 7) existed on 53 males collected above Huntington Lake, Fresno County, California (MAC), one male from Alpine county and another from Tuolumne County, California (CAS), two males from Lone Pine, California (SNOW), six males from Chaffee County, Colorado (CAS), two males from near Raymond, Colorado (CNC), three males from Cache County, Utah (USU), and one male from near Lucerne, British Columbia (CAS). The 53 males from above Huntington Lake (collected in a Malaise trap set across a tributary to Rancheria Creek) were part of a series, collected concurrently, that included three males with the predominant form of terminalia and two males with terminalia that were intermediate in terms of overall size, size of the aedeagal apodeme, and length of setae forming the gonocoxite fringe. I consider males with this much smaller form of terminalia (due largely to reduction in the hypandrium) to be structural variants of *M. collusor*, based on the presence of intermediates and the fact that other structural variation in terminalia is common among *M. collusor* males, as mentioned above.

### ***Metachela convexa*** **MacDonald, New Species**

Description.—*Male:* Body length, including terminalia, ca. 3.8 mm. In general, matching the generic description with regard to coloration, vestiture, and venation. Fore femora without fringe of long setae on inner surface; relatively stout, less than 4 times longer than greatest width, with basoventral setae about as long as greatest width. Terminalia (Fig. 1) with large, strongly convex gonocoxites that overlap hypandrium below and epandrial lobes above; apical fringe on gonocoxites with longest setae shorter than epandrial lobes; median margin of epandrial lobes expanded into rounded, apicodorsal process lined with black setulae. *Female:* unknown; none associated with concurrently collected males.

Type material.—HOLOTYPE male, top label "U. S. A.: California:/Shasta County, Honn/Creek Campground, /Hat Creek, 29 km. SE./Burney, 30-VII-1974" and bottom label "Paul H. Arnaud, Jr./Calif. Acad. Sci. Coll."; macerated terminalia in glycerin microvial attached to pin. Holotype deposited in the California Academy of Science Collection (CAS). PARATYPES.–2 males. California: Shasta Co., Lassen Volcanic Nat. Park, 2.4 km. W. Kings Cr., July (CAS). Oregon: Klamath Co., 5 mi N. Chiloquin, on Williamson R., June (CAS).

Remarks—The specific epithet refers to the large, strongly convex gonocoxites that are diagnostic for this species. Nothing is known about the biology of *M. convexa* which, based on only 3 specimens, appears to be restricted to northern California and southern Oregon (Fig. 8).

## ACKNOWLEDGMENTS

I thank the following individuals for the loan of material: P. H. Arnaud, Jr. (CAS); R. W. Brooks (SNOW); P. J. Clausen (UMSP); S. Frommer (UCR); W. J. Hanson (USU); L. Knutson (USNM); J. K. Liebherr (CU); R. T. Schuh (AMNH); H. J. Teskey (CNC); W. J. Turner (JAMES); D. W. Webb (INHS); and H. V. Weems (FSCA).

Sincere appreciation is extended to the Dipterists in the Biosystematics Research Centre, Ottawa, where I spent a sabbatic leave in the fall of 1984. Special thanks are given to H. J. Teskey for his generous assistance during initial study, to K. V. G. Smith for examining the type of *Metachela albipes*, to J. Cumming and W. P. McCafferty for critically reading the manuscript, and to Arwin Provonsha for preparing the illustrations. This paper is Purdue Agricultural Experiment Station journal No. 11,534.

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# SEXUAL DIMORPHISM IN SIZE OF ADULTS AND PUPARIA OF *TETANOCERA FERRUGINEA* FALLÉN (DIPTERA: SCIOMYZIDAE)

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*Abstract.*—Adults and puparia of *Tetanocera ferruginea* Fallén are sexually dimorphic. In both stages, the size of the female is significantly greater than that of the male. Based on a biometric study, puparial length demonstrated that the sex of the adults could be estimated before emergence with an 80.4% precision. This information on sexual differentiation is important for field studies of populations of sciomyzid flies.

*Key Words:* Sciomyzidae, *Tetanocera ferruginea,* sexual dimorphism, size, adults, puparia

In general, numerous Diptera (Vargas 1968) and many other insects (Mellini 1973) show sexual dimorphism in the size of adults and immature stages. Usually, the male is smaller than the female. For the puparia, the determination or separation of sexes is based on few parameters: average weight (Féron and Serment 1963), color of the puparium (e.g. *Lucilia cuprina* Wiedemann (Whitten 1969)), examination after a nontoxic chemical treatment (e.g., *Musca autumnalis* De Geer (Tung et al. 1969)), external morphological characters (Kuitert 1975), or microscopic examination through the puparium (Cunningham 1966).

Other studies have shown that for Diptera, sexual dimorphism rarely appears among the larvae (Atchley 1971) and never in the eggs. However, dimorphism of larvae and eggs does occur in Homoptera (Monti 1955) and Lepidoptera (Levesque 1963).

The determination of sex of the immature stages of the Sciomyzidae is an important factor in studies of the basic biology of these flies. Sexual differentiation is particularly important for field studies of population dynamics of these flies, or when an intensive rearing program is part of a biological control project.

From 1982 to 1987, samples of sciomyzid species were collected periodically from an aquatic habitat near Avignon, in southern France. Studies revealed that there was a distinct variation in the size of adults and puparia of the species of flies, and particularly of *Tetanocera ferruginea* Fallén, which was the most common species in the sciomyzid population of this habitat (Vala and Manguin 1987).

## MATERIALS AND METHODS

*T. ferruginea* has 3 or 4 annual generations (Vala and Haab 1984) and the flight period extends from late March through November. The species overwinters as diapausing puparia (Berg et al. 1982).

The puparium is black, oval, measuring 7.3 to 7.7 mm long and 3.1 to 3.4 mm wide (Fig. 1). The anterior part has the circular line of dehiscence for adult emergence. The raised posterior end has a vestigial respiratory disc and vestigial lobes of the third-instar larva. The spiracles are above the puparium, which is an adaptation for flotation.

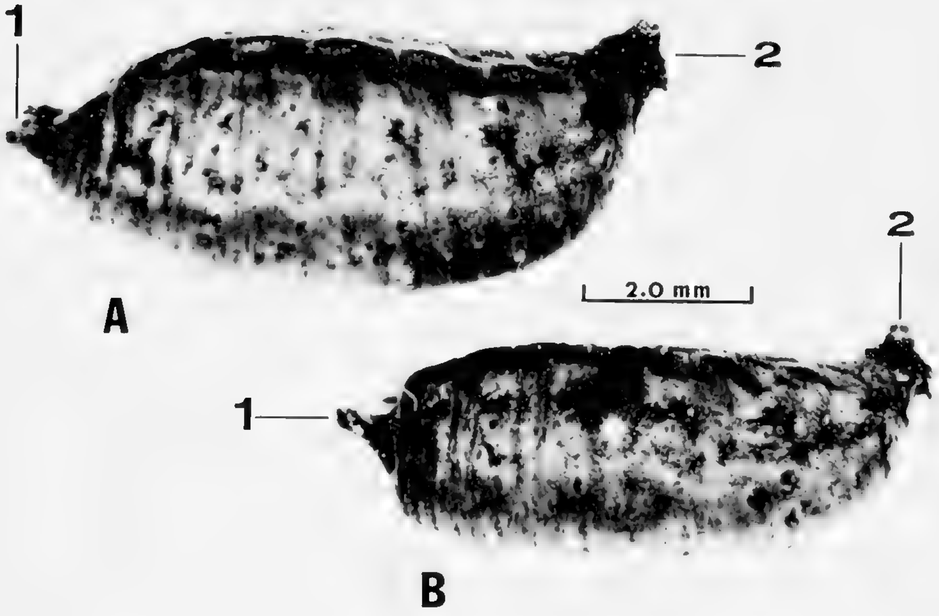

Fig. 1. Lateral view of the puparium of *T. ferruginea.* A, female puparium; B, male puparium. 1, anterior spiracle; 2, posterior spiracle.

The puparia examined were from laboratory cultures of *T. ferruginea* which were held in incubators at 20°C with a photoperiod of LD 16:8. The larvae were reared in petri dishes (17 cm diameter × 5 cm deep) with 5 mm of tap water, which contained one sciomyzid larva and 10 snails each of the species *Physa acuta* (Draparnaud) and *Lymnaea palustris* (Müller). These species of prey were readily attacked by larvae of *T. ferruginea* and 20 prey per unit were more than adequate for one larva (Manguin et al. 1986, 1988).

All specimens were measured with a 1/50 mm Kanon gauge. The length of the adults was measured from the frons to the terminalia; the width was the distance between the lateral margins across the median part of thorax. For puparia, three parameters were measured: length, width, and height. All measurements were of the distance between the extremities along or across the median part of the puparia. After measurements were taken the puparia were returned to the incubator and held for emergence of the adult to verify the sex of each specimen.

## RESULTS

*Sexual dimorphism of adults:* Measurements of the length and width of 30 specimens of each sex produced a bimodal curve for the distribution of size. (Fig. 2).

Males, the smaller sex, represented the first peak of the curve, averaging 9.6 mm in length (range 7.9 to 10.5 mm) and 1.9 mm in width (range 1.6 to 2.5 mm). The larger females represented the second peak with an average of 10.9 mm in length (range 9.9 to 11.9 mm) and 2.2 mm in width (1.7 to 2.8 mm).

These two parameters showed highly significant differences between males and females ($P < 0.01$). However, the measurements of the sizes of males and females produced an overlapping zone which was narrower for length than for width.

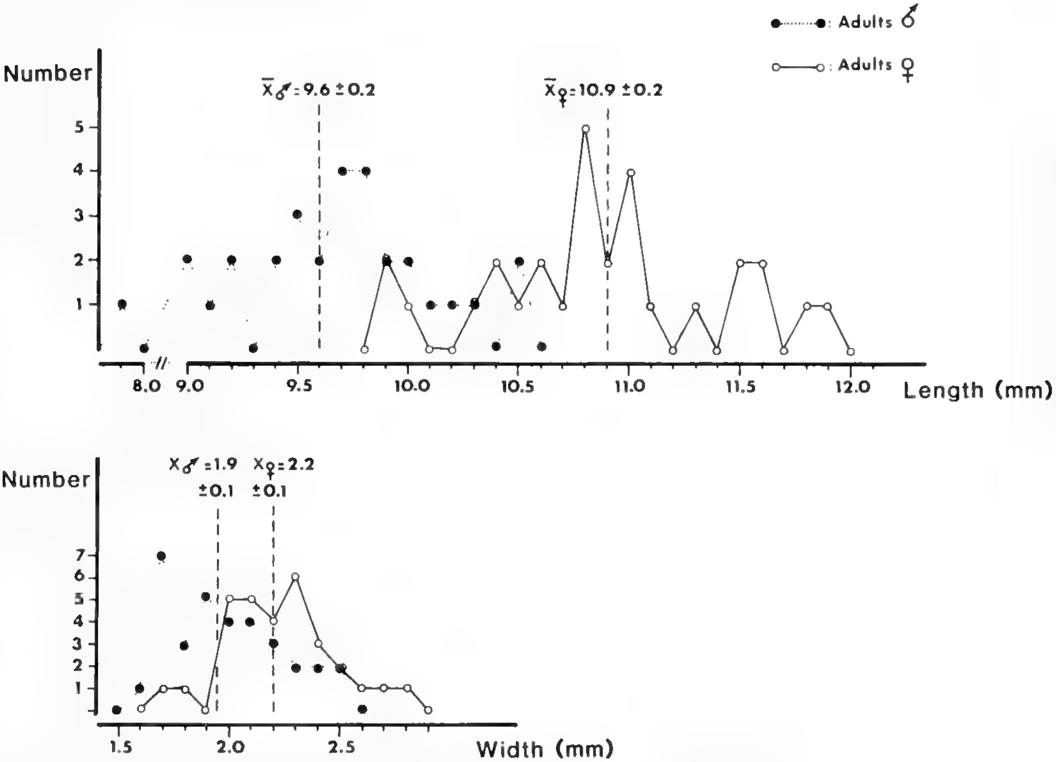

Fig. 2. Distributions of length and width (mm) of adults of *T. ferruginea.* Males = broken line, solid circle; females = solid line, clear circle; n = 30 specimens per sex.

*Sexual dimorphism of puparia:* We measured unemerged puparia for predicting the sex of an adult. After an adult had emerged, the empty puparium, minus the cephalic caps, again was measured for comparison with the observed sex of the adult specimen.

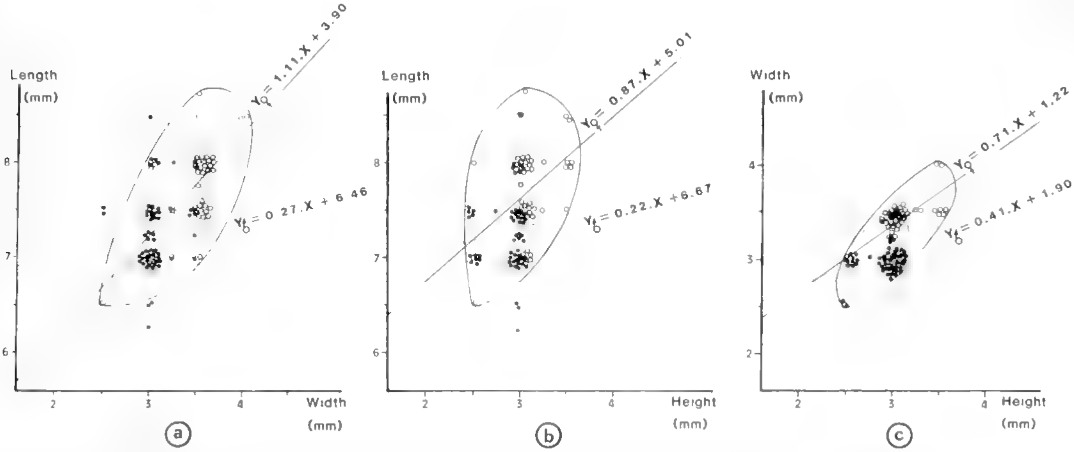

Fig. 3. Regressions between sizes and unemerged puparia of *T. ferruginea.* Males = broken line, solid circle; females = solid line, clear circle; a, length/width; b, length/height; c, width/height.

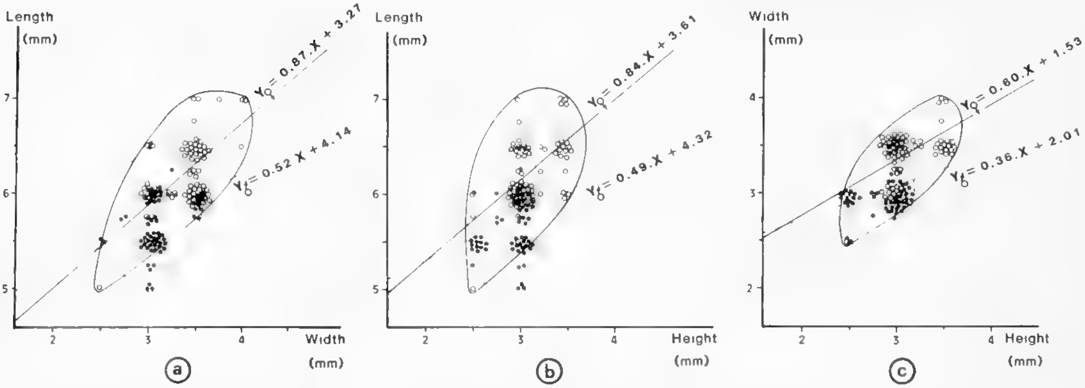

Fig. 4. Regressions between sizes of puparia of *T. ferruginea.* Males = broken line, solid circle; females = solid line, clear circle; a, length/width; b, length/height; c, width/height.

The results in Table 1 indicate that the size of the female puparium is significantly larger than that of the male ($P < 0.01$).

The size distribution was established by correlating paired dimensions of unemerged puparia (Fig. 3) and emerged puparia (Fig. 4). For males, the distribution of every measurement was narrow, regardless of the measurement considered. This was confirmed by the coefficient of variation which varied within narrow limits, from 5.6 to 7.1 (Table 1). For females, the data clusters on the graph were larger and defined a loose type of dispersion. The coefficient of variation was significantly higher and ranged from 5.9 to 8.5.

In superimposing graphs obtained for both sexes (Figs. 3 and 4), the dispersion of the data was unwedged, particularly when the length of the puparium was considered (Figs. 3a,b and 4a,b). The width and height were highly different between the sexes, but these differences were not as important as those determined for the length (Figs. 3c, 4c).

In general, the correlations obtained (Figs. 3, 4) were defined by equations in which the range slope varied between 0.22 and 0.52 for the males and between 0.60 and 1.11 for the females. These slopes, steeper for the females, revealed that the 3 parameters (length, width and height) evolved in a simultaneous manner. However, for males, the slopes were much more level and there was not much difference between parameters. Although the length increased, the width and height varied only slightly.

Table 1. Mean size (mm) in length, width, and height of male and female unemerged puparia and empty puparia of *T. ferruginea* (±standard deviation at 5% threshold). CV (%): coefficient of variation; n = number of measured puparia.

| | | Unemerged puparia | | | Emerged puparia | | |
|---|---|---|---|---|---|---|---|
| | | Length | Width | Height | Length | Width | Height |
| | | | n = 57 | | | n = 72 | |
| Males | $\bar{x}$ (mm) | 7.3 ± 0.11 | 3.1 ± 0.06 | 2.9 ± 0.05 | 5.7 ± 0.08 | 3.1 ± 0.05 | 2.9 ± 0.05 |
| | CV (%) | 5.8 | 7.0 | 7.1 | 5.6 | 6.8 | 7.0 |
| | | | n = 48 | | | n = 71 | |
| Females | $\bar{x}$ (mm) | 7.7 ± 0.14 | 3.4 ± 0.08 | 3.1 ± 0.07 | 6.2 ± 0.09 | 3.4 ± 0.06 | 3.1 ± 0.06 |
| | CV (%) | 6.3 | 8.5 | 7.5 | 5.9 | 7.7 | 8.2 |

The length of a puparium was more definitive than either the width or height as a character to recognize the sex.

*Estimation of the sex of the puparium:* We measured the length of 240 unemerged puparia and estimated that 143 puparia would be male and 97 puparia would be female (Table 2). After adult emergence these predictions were proven correct in 80.4% of cases. The results were more reliable with males, with only 9.8% of error, whereas measurements of the females were 34% erroneous. This difference was explained by the larger spread of measurements for the female, shown by the coefficient of variation (Table 1).

## DISCUSSION

There is sexual dimorphism in sizes of adults and puparia of *T. ferruginea.* For adults, the length and width of the females was significantly greater than for males. Among the puparia, the parameters of length, width, and height increased proportionally for the females. Consequently, the shape of female puparia was more oval with the dorsal side slightly convex. For the males only the length of the puparia varied. The width and height were relatively constant; and in lateral view, the dorsal surface of the puparium was more rectilinear.

The possibility of determining the sex of the flies prior to emergence, with an 80.4% accuracy, is important not only for population studies of field collected material, but also for purposes of release in biological control programs. The sexual differentiation permits an easy manipulation of inert pupae rather than active living flies, and eliminates the need to hold for adult emergence if sampling only is required. An additional benefit of this method would be its use in the study of those parasites that emerge from puparia, such as many species of Ichneumonidae (Manguin 1987). By determining the sex of the puparia, the distribution of parasites emerging from male and female hosts can be established. This was not possible when the sex of the host was based only on the adult specimen.

Table 2. Estimation of the sex of puparia determined by the measurement of the length.

| | Number Puparia Examined | Percentage Accuracy |
|---|---|---|
| Males | 143 | 90.2 |
| Females | 97 | 66.0 |
| Total | 240 | 80.4 |

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# INFLUENCE OF TEMPERATURE AND PHOTOPERIOD ON EARLY DEVELOPMENTAL RATE OF *TENODERA SINENSIS* SAUSSURE (MANTODEA: MANTIDAE)

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*Abstract.*—Rate of development for the first two instars of the mantid *Tenodera sinensis* (Saussure) increased with increasing temperature for cohorts maintained at 20°C, 25°C and 32°C. An increase in incubation temperature from 20°C to 32°C decreased time in instar by more than two thirds for photoperiods of 8L:16D, 16L:8D and 24L:0D. The effect of photoperiod was less pronounced, partly because immobile mantid nymphs could feed in the dark when nocturnally active prey came into contact with them. Total prey consumed and biomass of nymphs at ecdysis did not differ among treatment groups. The effect of temperature apparently was to increase feeding rate, thereby decreasing the time required to consume the threshold amount of prey biomass necessary to trigger molting.

*Key Words:* Mantodea, Mantidae, *Tenodera sinensis,* development, temperature, photoperiod, predators

As with other univoltine insects inhabiting temperate regions, the life cycle of the mantid *Tenodera sinensis* (Saussure) is constrained by seasonality: it must emerge early enough in the spring to complete its life cycle before the onset of freezing temperatures in the fall, yet not so early that it is in danger of late spring frosts. In addition to these abiotic limits, prey are scarce early in the spring and late in the summer and fall, so that food limitation effectively narrows the temporal window available for success in terms of survival and fecundity (Eisenberg et al. 1981, Hurd and Eisenberg 1984).

There are three potential disadvantages to emergence early in the spring: 1) prey are scarcer than later in the spring, 2) temperatures are cooler and the risk of freezing from a late frost is significant, and 3) photoperiods are shorter. Food shortages for first instar *T. sinensis* nymphs, decrease survivorship and retard development (Hurd and Eisenberg 1984, Hurd and Rathet 1986). The importance of temperature to insect development in general has been well-documented (e.g. Tauber et al. 1986, Bowler and Cossins 1987), which led us to ask how important this abiotic factor may be to growth rate of *T. sinensis.* Photoperiod, which increases less dramatically than temperature from early to late spring, might also be important to visual predators such as mantids because it presumably determines the amount of time available for prey capture. Here we ask how temperature and photoperiod affect developmental rate in newly hatched nymphs of *T. sinensis.*

## Materials and Methods

Oothecae of *T. sinensis* were collected from New Castle County, Delaware, during the winter of 1988 and kept in the laboratory at 10°C. These oothecae were subsequently incubated at 25°C to induce hatching. Upon hatching, nymphs were divided among three treatment groups of 30 nymphs each, which differed in hours of light vs. dark per day: 8L:16D, 12L:12D, and 24L:0D. The entire light:dark series was run at three temperatures with three separate cohorts: 20°C, 25°C, and 32°C. The broad range of light and temperature was chosen to provide the greatest opportunity for these abiotic factors to influence development. Five additional nymphs were kept in total darkness at 25°C and otherwise treated as above, to serve as a check on whether any feeding could take place in the dark.

Nymphs were housed individually in 130 ml glass vials fitted with plastic lids, which were ventilated with fine mesh brass screen. Cotton-tipped swabs were inserted through holes in the caps and the tips were wetted daily with distilled water. Mantid nymphs were allowed to crawl into the vials upon hatching, and were not handled thereafter in order to avoid injury. All mantid nymphs were provided prey *ad libitum,* in the form of apterous *Drosophila melanogaster* (Meigen). Numbers of flies consumed in whole or in part were recorded, and all flies were replaced daily.

The first 10 nymphs in each group to molt were killed by freezing, measured for body length (top of head to tip of abdomen), dried at 60°C for 48 h and weighed. This experiment was carried out for the first two stadia.

Data obtained in this experiment generally did not meet the homogeneity of variance criterion necessary for the application of parametric ANOVA. Therefore the effects of photoperiod and temperature were analyzed using nonparametric Kruskal-Wallis tests (Sokal and Rohlf 1981).

## RESULTS

Temperature had the most pronounced effect on developmental rates for both instars. Examination of the pattern of molting among experimental cohorts revealed a consistent decline in stadium length with increasing temperature for all three photoperiods (Table 1).

The effect of photoperiod was both less dramatic and less consistent. Photoperiod was not correlated with developmental rate within temperature groupings for first instars (Table 1). The only significant difference within a temperature group was a slightly greater mean stadium length in nymphs exposed to 16 hours of light at 25°C. Photoperiod had a greater effect on developmental rate of second instars than firsts. Stadium duration declined significantly between the 8L:16D and 16L:8D groups for nymphs incubated at 20°C and 32°C, but not at 25°C (Table 1).

Feeding rates of nymphs during both stadia were also more consistently related to temperature than to photoperiod. During first stadium, feeding rate increased with increasing temperature for all photoperiods (Table 2), but was not affected by photoperiod. During second stadium, feeding rate also increased significantly with increasing temperature for all photoperiods (Table 2). As with developmental rate (Table 1), feeding rate increased significantly between the 8L:16D and 16L:8D groups of nymphs exposed to 20°C and 32°C, but not 25°C.

Total flies consumed was not related either to temperature or to photoperiod. Mean number of flies eaten by first instars ranged from 19–22 among the nine experimental groups; for second instars the range was 35–44 flies. There was also no significant difference in biomass attained by nymphs among the various treatment groups. During first stadium, mean nymph biomass ranged from 2.2–2.9 mg; during second stadium the range was 5.3–6.1 mg.

The five first instar nymphs kept in total darkness (0L:24D) were able to feed and to complete the instar. In fact there was no significant difference between these nymphs and those kept at 24L:0D, either in rate of maturation or in feeding rate. Observations of nymphs made in the dark under red light indicated that these flies were active in the

Table 1. Mean stadium length in days (±SE) for *T. sinensis* nymphs. N = 10 in each cell. Asterisks indicate $P < 0.001$ (Kruskal-Wallis test) for differences within rows and columns.

| | | Temperature (°C) | | |
|---|---|---|---|---|
| | | 20 | 25 | 32 |
| First instar: | | | | |
| Light : dark regime | 8L:16D | 16.7 (0.21) | 8.9 (0.10) | 5.4 (0.16)* |
| | 16L:8D | 17.3 (0.49) | 9.4 (0.16) | 5.0 (0.00)* |
| | 24L:0D | 16.9 (0.10) | 8.0 (0.00) | 5.0 (0.00)* |
| | | ns | * | ns |
| Second instar: | | | | |
| Light : dark regime | 8L:16D | 27.2 (0.66) | 9.4 (0.24) | 6.4 (0.40)* |
| | 16L:8D | 15.6 (0.60) | 9.4 (0.51) | 5.0 (0.31)* |
| | 24L:0D | 16.2 (0.49) | 9.4 (0.24) | 5.0 (0.00)* |
| | | * | ns | * |

dark, and were captured by stationary mantid nymphs when contact was made. Therefore, *T. sinensis* nymphs are at least capable of night feeding by tactile cues, even when they cannot see prey. This, of course, does not explain the significant effects of photoperiod on second instar nymphs (see above).

## DISCUSSION

Our results suggest that temperature is more important than photoperiod to developmental rates of the first two instars of *T. sinensis.* The initial assumption that photoperiod places a limit on time for prey capture was found to be incorrect, at least during first stadium. However, we do not know to what extent night feeding is a useful adaptation, or simply a laboratory artifact of confining nymphs to vials in which nocturnally active prey are abundant. Some ambush predators, such as thomisid spiders which use flowers as feeding sites, routinely feed at night as well as during the day (Morse 1981, R. Fritz pers. comm.). However, mantid nymphs are not flower specialists, which calls into question how often prey are likely to blunder into them in the dark in the absence of such an attractant.

Although temperature has been found to have profound effects on body size and even adult fecundity in other insects (e.g. Laugh-

Table 2. Mean (±SE) feeding rates of mantid nymphs fed *ad libitum,* in terms of number of flies consumed/nymph/day. Asterisks indicate $P < 0.001$ (Kruskal-Wallis test) for differences within rows and columns.

| | | Temperature (°C) | | |
|---|---|---|---|---|
| | | 20 | 25 | 32 |
| First instar: | | | | |
| Light : dark regime | 8L:16D | 1.34 (0.34) | 2.08 (0.09) | 3.58 (0.14)* |
| | 16L:8D | 1.32 (0.05) | 1.92 (0.09) | 4.43 (0.11)* |
| | 24L:0D | 1.34 (0.08) | 2.27 (0.09) | 3.85 (0.11)* |
| | | ns | ns | ns |
| Second instar: | | | | |
| Light : dark regime | 8L:16D | 1.73 (0.08) | 4.87 (0.04) | 5.49 (0.56)* |
| | 16L:8D | 2.88 (0.16) | 3.74 (0.45) | 8.16 (0.43)* |
| | 24L:0D | 2.79 (0.14) | 4.81 (0.37) | 8.80 (0.34)* |
| | | * | ns | * |

lin 1964), there was no relationship between temperature and size at ecdysis for first and second instar *T. sinensis.* Additionally, there was no relationship between temperature and total prey consumed. Feeding rate, however, consistently increased with increasing temperature. Therefore, the effect of increasing temperature was to decrease the time necessary to consume a threshold amount of prey biomass in order to trigger molting.

These results raise a question about the life history strategy of this species: Why does egg hatch occur so early, at a risk of starvation and late frost, when hatching a few weeks later would expose them to increased temperature and prey density, both of which facilitate faster development? For instance, 20°C and 25°C correspond roughly to daytime temperatures during late April and late May, respectively, in our area (Bair and Ruffner 1985). This five degree increment resulted in a 43% decrease (from 33 to 19 days) in the time it took to complete both first and second stadia among mantid nymphs fed *ad libitum* in our experiment (16L:8D). Nymphs which have hatched at the end of April in the field have taken up to 45% longer to develop through second instar than in this experiment (Rathet and Hurd 1983, Hurd and Eisenberg 1984), but field conditions entail variable temperatures as well as food limitation.

If abiotic advantages *per se* do not entirely account for early hatching in this species, what biotic factor(s) might be responsible? Possibilities include avoidance of predators (or parasites), and reduction in competition. Other mantid species, sympatric with *T. sinensis* here and abroad, hatch later in the spring (Rathet and Hurd 1983, Hurd 1988). These differences in egg phenology could mitigate interspecific competition by reducing size overlap among these species (Hurd and Eisenberg 1989); mantids of different sizes take different sized prey (Bartley 1983). Furthermore, larger mantids have a greater total range of prey sizes they can effectively take than smaller ones (Bartley 1983). However, a disparity in size can also result in predation of later hatching (smaller) nymphs by those emerging earlier (Hurd 1988). Therefore, early hatching may confer an advantage to *T. sinensis* over other sympatric mantid species, which offsets the apparent abiotic disadvantages.

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# A NEW SPECIES OF *HORISMENUS* (HYMENOPTERA: EULOPHIDAE) PARASITIC ON THE LESSER CORNSTALK BORER, *ELASMOPALPUS LIGNOSELLUS* (LEPIDOPTERA: PYRALIDAE)

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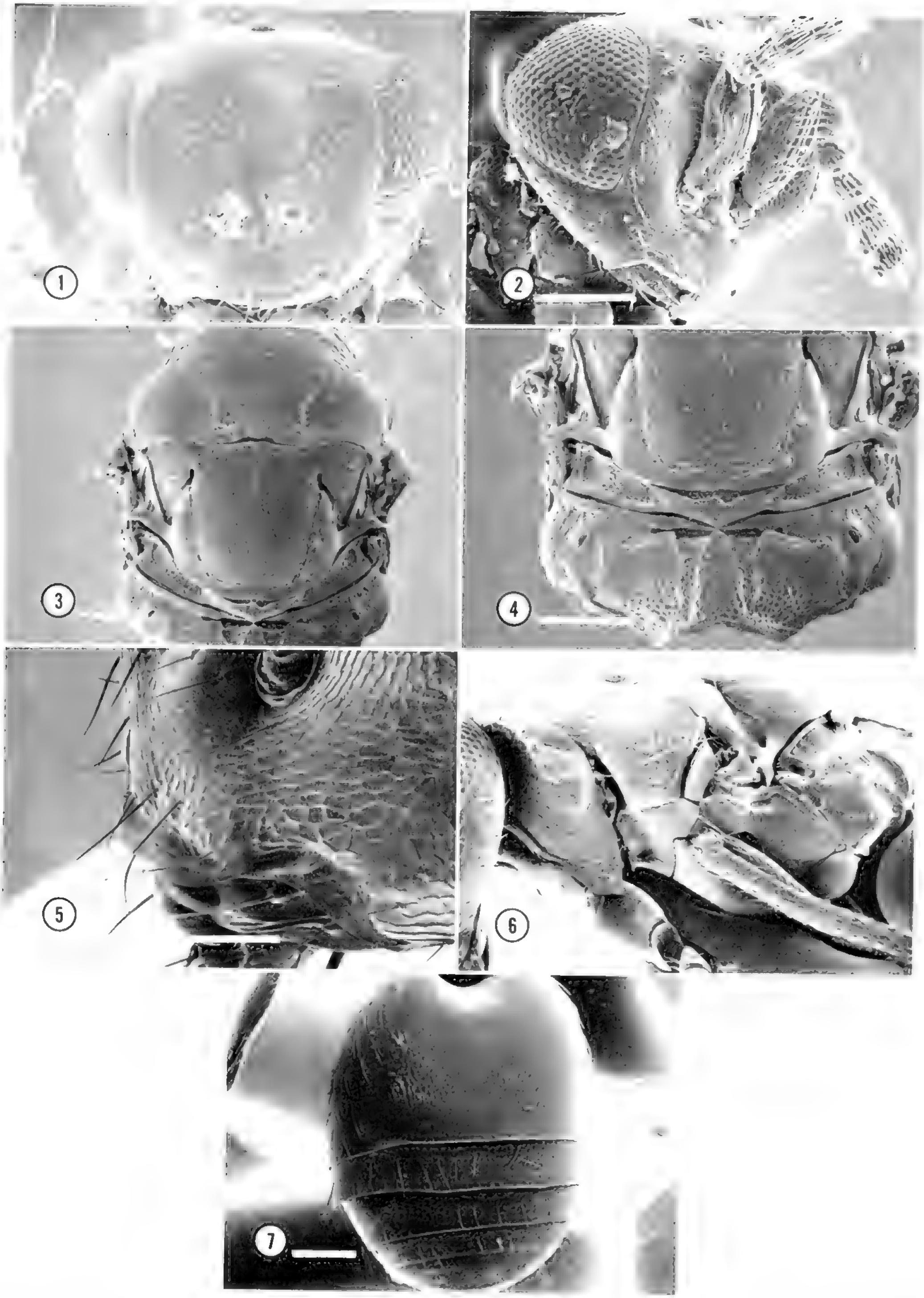
*Abstract.*—A new species of ***Horismenus*** **(*elineatus*** Schauff) (Eulophidae: Entedoninae) is described and illustrated. This species is a primary gregarious endoparasitoid of the lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller), and is native to Bolivia. This species is being studied for possible introduction into the United States for control of the borer.

*Key Words:* biological control, Chalcidoidea, corn

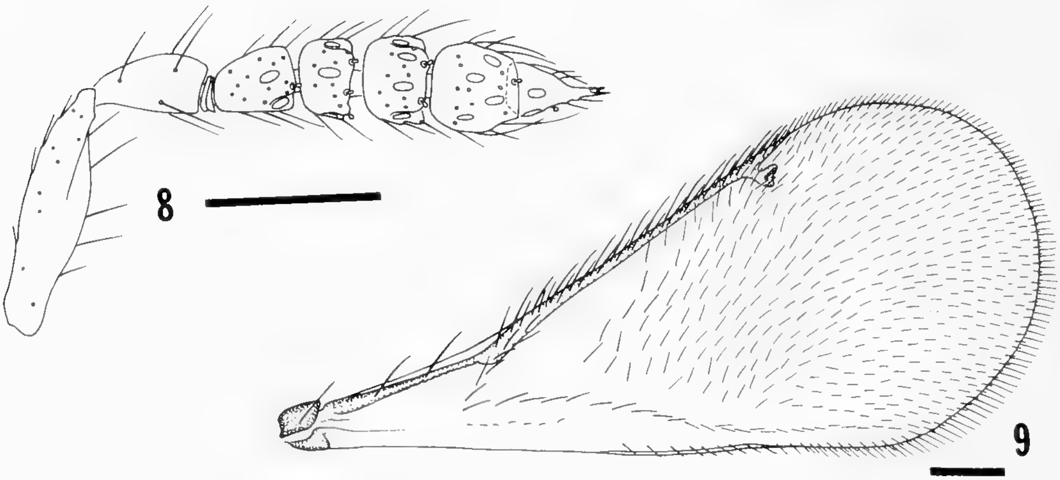
The lesser cornstalk borer, *Elasmopalpus lignosellus* (Zeller), is a pest of corn in the southern United States because it damages the lower part of the cornstalk (Metcalf et al. 1962). During a search for natural enemies in South America, a new species of eulophid was discovered in Bolivia that was attacking the larvae of the borer. This species was submitted to the USDA's Systematic Entomology Laboratory for identification, and the specimens were found to represent an undescribed species in the genus *Horismenus.* I am naming this species so that quarantine, importation, and work on the biology can proceed.

Species of *Horismenus* can be differentiated from other eulophids by the following characters: scutellum with one pair of setae; submarginal vein of forewing with 2 setae (subfamily Entedoninae); median propodeum with a smooth or lightly sculptured raised area bordered by sunken, usually sculptured, areas (Fig. 4); scutellum generally with a nearly complete median longitudinal suture; posterior edge of prepectus interrupted (indented) by anterior margin of mesosternum (Fig. 6); dorsellum V-shaped (pointed) postero-medially; petiole reticulate; second metasomal tergum larger than remaining terga, often covering half the length of the metasoma; stigmal vein (Fig. 9) short, and without a distinct petiole.

The genera most easily confused with *Horismenus* are *Paracrias* and *Edovum,* which also have similar patterns of carinae on the propodeum. But, species of *Paracrias* do not have the posterior edge of the prepectus interrupted and the postero-median dorsellum is not V-shaped, but straight (Schauff 1985). Species of *Edovum* (Grissell 1981) can be distinguished by the presence of an epicnemial carina on the anterior mesosternum and the presence of longitudinal striae on the petiole. In addition, *Paracrias* species are generally parasitic on weevil larvae and the single known species of *Edovum* is parasitic in the eggs of Chryso-



Figs. 1–7. Scanning electron micrographs of *Horismenus elineatus* n. sp. 1, Head of ♀, frontal view. 2, ♂ Head and antennae. 3, ♀ Scutum and scutellum, dorsal view. 4, ♀ Propodeum, dorsal view. 5, ♀ Clypeus and lower face, lateral view. 6, ♀ Mesosoma, lateral view. 7, ♀ Metasoma, dorsal view. Scale line = 0.1 mm.



Figs. 8–9. 8, ♀ antenna. 9, ♀ forewing. Scale line = 0.1 mm.

melidae. *Horismenus* is generally not associated with Coleoptera nor are they egg parasites.

### ***Horismenus elineatus* Schauff,** **New Species**

Female.—Length 1.1–1.4 mm. Color black except the following: apices of all femora, lateral surface of foretibiae, base of mid and hindtibiae, first 3 tarsomeres of all legs, light yellow to white; mid and hindtibiae sometimes dark to light brown, fourth tarsomere sometimes brown.

Head.—Antennae (Fig. 8) with three ring-like anelli; funicular segments wider than long; lower margin of clypeus protruding out over mandibles (Fig. 5); entire face (including intertorular area), frons, and vertex lightly to distinctly alutaceous (Fig. 1).

Mesoscutum alutaceous; notauli distinct posteriorly, fading anteriorly; scutellum alutaceous except smooth at posterior edge, more striate outside of the lateral sutures, sculpture often slightly less strongly expressed than on scutum, but broadening slightly behind the axillae with lateral grooves present only in the expanded area (Fig. 3); median longitudinal groove present only in anterior ¼ to ⅓ and often only discernible as a slight change in the pattern of sculpture; lateral propodeum (Fig. 4) covered by alutaceous sculpture which is strongest medially and posteriorly.

Metasoma approximately 1.2× as long as wide (excluding petiole), shorter than the mesosoma; petiole 1.2 to 1.0× as long as wide, tergum 2 covering ½ to nearly entire length of metasoma (posterior terga tend to telescope inward in air dried specimens); lightly alutaceous over dorsal and lateral surface, expect near basal fovea where the surface is smooth and shining (Fig. 7).

Male.—Length 1.1–1.2 mm. Similar to the female except the following: antenna (Fig. 2) with scape swollen medially, ventral sensory ridge extending nearly its entire length. Metasoma about as long as wide (see below).

There is considerable variation in the appearance and relative length to width of the metasoma in both males and females because of the way in which specimens are preserved and mounted. When air dried, the terminal segments of the metasoma tend to telescope inward. In some males, nearly all the segments past the second may be hidden from view. Otherwise, very little morphological variation was evident in the specimens available for study.

Using the key to North American species

of *Horismenus* (Burks 1971), this species would key to *lixivorus* (Crawford) because it possesses dark tibiae combined with even sculpturing of the scutellum. It is easily separated from that species by the lack of a distinct longitudinal suture on the scutellum (suture present for about 3/4 length of scutellum in *lixivorus*); the sculpturing of the median propodeum (raised median area smooth in *lixivorus*); and the length of the female metasoma (shorter than the head and thorax in *elineatus,* longer than the head and thorax in *lixivorus*). There is no key to South America *Horismenus* species. However, I have examined representative specimens of most of the described species from the Neotropics and they share neither the darkened femora and tibiae nor the almost complete lack of a longitudinal scutellar suture.

Distribution.—Known only from Bolivia.

Discussion.—The placement of this species in *Horismenus* changes, to some degree, the traditional limits of the genus. One of the characters used to define *Horismenus* has been the presence of a more or less complete longitudinal scutellar groove. But, my study of the species of *Horismenus* and of related genera has shown that not only is the length and distinctness of the groove variable in *Horismenus,* but that it also occurs in other genera (e.g. *Alachua* in the New World (Schauff and Boucek 1987) and *Parzaommomyia* from Australia (Boucek 1988)). Hence, the presence of this character can no longer be considered a synapomorphy for species in the genus.

Biology.—This species is a primary gregarious endoparasite of the last three larval instars of *E. lignosellus.* It pupates in the dead body of the host (J. W. Smith, pers. comm.). Whether this species will attack related lepidopterous hosts is being investigated.

Types.—Holotype ♀ on point, antennae and forewing slidemounted: Bolivia, Santa Cruz, CIMCA, 22-IX-1988. G. Pruitt. T88048. Ex. *Elasmopalpus lignosellus* (Pyralidae). Antennae and forewing slide mounted. Deposited in the U.S. National Museum of Natural History. Paratypes: 18 ♀ and 1 ♂ with same data as holotype. 82 ♀ and 5 ♂ with data: Bolivia, 10-VI-1976. E. Colque A. ex. *Elasmopalpus lignosellus.* Paratypes are deposited in the USNM and the following institutions: Texas A & M Univ., College Station; Canadian National Collection, Ottawa; British Museum (Natural History, London).

Etymology.—The species epithet *elineatus* is formed from "e" meaning not or without and "linea" for line and refers to the lack of a distinct longitudinal scutellar line or groove.

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# *MEGALONOTUS SABULICOLA* (HETEROPTERA: LYGAEIDAE), AN IMMIGRANT SEED PREDATOR OF *CENTAUREA* SPP. (ASTERACEAE): DISTRIBUTION AND HABITS IN EASTERN NORTH AMERICA

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*Abstract.*—The North American distribution of *Megalonotus sabulicola* (Thomson), a European rhyparochromine lygaeid accidentally introduced to the Pacific Northwest and East Coast, is reviewed. Delaware, New Jersey, Pennsylvania, Rhode Island, Virginia, and West Virginia are listed as new state records, and additional localities are cited for Maryland and New York. In the mid-Atlantic region this bug feeds mainly on fallen seeds of spotted knapweed, *Centaurea maculosa* Lam. (Asteraceae), a noxious weed of western rangelands and invasive plant in ruderal habitats of eastern North America. This bivoltine seed predator could be considered a beneficial immigrant because it destroys spotted knapweed seeds. Its effects on plant density, however, apparently are negligible. Characters are provided that facilitate recognition of this Palearctic bug in the New World fauna.

*Key Words:* immigrant insect, distribution, eastern North America, seed predation, spotted knapweed, *Centaurea maculosa*

*Megalonotus sabulicola* (Thomson) is a widespread Old World lygaeid known in Europe to range from Sweden and England south to the Mediterranean countries, where it seems particularly common, and east to the European U.S.S.R; it also occurs in northern Africa (Morocco) and in Turkey, Syria, and Israel (Slater 1964). In Europe, *M. sabulicola* was long considered a subspecies of *M. chiragra* (F.) and is so listed in Slater's (1964) world catalog. But, as Southwood (1963) pointed out, the two overlap in their range and sometimes even in habitat; therefore, *M. sabulicola* cannot be considered a subspecies of *M. chiragra.* Southwood (1963) and Roubal (1965) determined that these sympatric bugs do not substantially intergrade and concluded that they represent distinct species, although morphological separation is not always clearcut.

The habits of *M. sabulicola* in Europe are not well known. It has been collected from the litter layer in various microhabitats and apparently is most common in sandy areas (Butler 1923, Southwood and Leston 1959). Pfaler (1936) reported that adults overwinter and that Finnish populations are bivoltine. Several workers have provided ecological notes (Slater 1964 and references therein), but detailed information on host plants and biology is lacking for European populations.

The first New World record of this rhyparochromine was from California (as *Rhyparochromus chiragra californicus*) (Van Duzee 1928). Since then, *M. sabulicola* has been recorded in the Pacific Northwest from

British Columbia, Oregon, and Washington (Scudder 1960, 1961, Slater 1964).

Slater and Sweet (1958) first reported this immigrant lygaeid from eastern North America, listing it from three localities in Connecticut. Sweet (1964) gave Massachusetts (Cape Cod) as a new state record and additional Connecticut records. Inclusion of District of Columbia, New York, and Pennsylvania under the known eastern distribution of *M. sabulicola* (as *M. chiragra*) in the world lygaeid catalog (Slater 1964) was misleading. As Slater and Sweet (1958) discussed, these records represent quarantine interceptions at ports of entry rather than established populations. The only eastern records subsequent to Slater's (1964) catalog are ones likely to be overlooked: Ithaca, New York, cited without collection data (Pimentel and Wheeler 1973), and Talbot Co., Maryland, based on one female (Hoebeke 1977).

Because *M. sabulicola* had been intercepted at ports on produce originating in Czechoslovakia or France and because this species is less common in Great Britain than *M. chiragra,* Sweet (1964) suggested that continental Europe was the likely source of established eastern U. S. populations. Slater and Sweet (1958) postulated that *M. sabulicola* was introduced to the Northeast with imported plant material rather than with ships' ballast. A ballast origin of Pacific Northwest populations, however, is probable (Slater and Sweet 1958, Scudder 1961).

Herein, I give new distribution records of *M. sabulicola* in the eastern states and discuss its association with spotted knapweed, *Centaurea maculosa* Lam., a naturalized weedy composite of railroad right-of-ways and highway embankments. Characters allowing this immigrant heteropteran to be recognized in the Nearctic fauna are provided.

## Distribution in Eastern North America

In addition to published records from Connecticut, Maryland, Massachusetts, and New York, the following records are available for *M. sabulicola* in the East (Fig. 1). Except as noted, all collections were made under *Centaurea maculosa* by the author (AGW); collection data are cited for Pimentel and Wheeler's (1973) New York record from Tompkins Co. Voucher specimens have been deposited in the insect collections of Cornell University (CUIC), Pennsylvania Department of Agriculture (PDA), and U. S. National Museum of Natural History (USNM).


Fig. 1. Known distribution of *Megalonotus sabulicola* in eastern North America. Open circles indicate previously published records; closed circles represent new records.

DELAWARE: *New Castle Co.,* Newark, 15 Oct. 1987, AGW and T. J. Henry. MARYLAND: *Harford Co.,* I95 S, Aberdeen Proving Grd. exit, 15 Oct. 1987, AGW and T. J. Henry; *Prince Georges Co.,* I95 S nr. Laurel, 15 Oct. 1987, AGW and T. J. Henry. NEW JERSEY: *Atlantic Co.,* Richland, 7 Oct. 1987; *Cumberland Co.,* Vineland, 26–28 May 1979, E. R. Hoebeke. NEW

YORK: *Chemung Co.,* Rt. 427 w. of Chemung, 19 Oct. 1987; *Tioga Co.,* Rt. 79. 1 mi. e. of Richford, 29 Oct. 1987; *Tompkins Co.,* Savage Farm, Ithaca, 3 July, 1 Aug. 1966, on alfalfa. PENNSYLVANIA: *Bedford Co.,* Rt. 220, s. of Cessna, 3 May 1988; *Berks Co.,* 3 mi. e. of Bethel, 8 Oct. 1987; Rt. 183 n. of Leinbachs and Rt. 198 s. of Bernville, 22 Oct. 1987; *Blair Co.,* Frankstown, 17 Nov. 1987; Tipton, 17 Apr. 1988; *Bradford Co.,* Canton, 16 Oct. 1987; *Cumberland Co.,* I81 N, 2 mi. s. of Rt. 114 nr. New Kingstown; *Dauphin Co.,* Early Mill Rd., 4.5 mi. n. of Hershey, 10 Aug. 1987, in house; *Franklin Co.,* Rt. 75 s. of Metal; PA Turnpike w. of Blue Mtn. tunnel and w. of Rt. 997, 9 Oct. 1987; *Fulton Co.,* Rt. 30 e. and Rt. 16 s.e. of McConnellsburg, 9 Oct. 1987; PA Turnpike, Sideling Hill Plaza, 3 May 1988; *Huntingdon Co.,* Huntingdon, 17 Nov. 1987; *Lackawanna* Co., Rt. 9 (NE Ext., PA Turnpike) nr. Scranton, 31 Mar. 1988; *Lancaster Co.,* I283 W at Rt. 772 nr. Mount Joy, 29 Sept. 1987; Elizabethtown, 3 Aug. 1988, on *Pinus mugo*; *Lebanon Co.,* I81 N, nr. Rt. 934, 28 Sept. 1987; Rt. 934 nr. junc. Rt. 22 nr. Harper Tavern, 28 Sept., 8 Oct. 1987 and 24 Mar., 17 & 24 May, 1 & 17 June 1988, AGW, J. E. Fetter, & J. F. Stimmel; *Luzerne Co.,* Hazleton, 29 Oct. 1987; *Lycoming Co.,* Trout Run, 16 Oct. 1987; *McKean Co.,* Bradford, 16 Aug. 1988; *Mifflin Co.,* 8 mi. e. of Mt. Union, 17 Nov. 1987; *Perry Co.,* Rt. 322 nr. Millerstown, 19 Apr. 1988; *Schuylkill Co.,* I81 N, .5 mi. s. & 1 mi. n. of Pine Grove exit and s. of Ravine, 8 Oct. 1987, AGW and J. F. Stimmel; *Union Co.,* Rt. 15, 1.2 mi. s. of Lewisburg, 16 Oct. 1987; *Wyoming Co.,* Tunkhannock, 29 Oct. 1987. RHODE ISLAND: *Kent Co.,* I95S, n. of Rt. 102 n.e. of Exeter, 3 Dec. 1987; VIRGINIA: *Augusta Co.,* Staunton, 7 Apr. 1988; *Roanoke Co.,* Rt. 220 n. of Boones Mill, 10 Apr. 1988; *Rockbridge Co.,* Rt. 11, 2 mi. s. of Fairfield, 10 Apr. 1988; *Shenandoah Co.,* Rt. 11, 1 mi. n. of Edinburg, 26 Nov. 1987 and Rt. 11 s. of Edinburg, 3 Dec. 1987; *Wythe Co.,* junc. I81S & I77S nr. Ft. Chiswell, 22 Apr. 1988, AGW & T. J. Henry. WEST VIRGINIA: *Berkeley Co.,* I81S nr. Falling Waters, 26 Nov. 1987.

## HABITAT AND HOST PREFERENCES

Following the first Pennsylvania collection of *M. sabulicola,* a specimen taken in my house in Dauphin Co. on 10 August 1987, a survey was initiated to learn more about its distribution in the eastern states and to determine its host plant and habitat preferences. Slater and Sweet (1958) reported a close association of this lygaeid with cornflower or bachelor's-button, *Centaurea cyanus* L., in New England, and Sweet (1964) observed the bugs using their beaks to carry or drag fallen seeds to a sheltered site for feeding. This introduced species appears to compete poorly with native rhyparochromines and in New England is nearly always restricted to *C. cyanus* colonies growing in temporary habitats (Sweet 1964). Because the European *C. cyanus* is not extensively naturalized in Pennslyvania (Wherry et al. 1979), I began looking for *M. sabulicola* under spotted knapweed, *C. maculosa,* a common European weed that grows in ruderal situations similar to those in which Slater and Sweet (1958) encountered *C. cyanus* and associated populations of *M. sabulicola,* i.e. early-succession xeric sites.

Nymphs and adults were found initially by looking under *C. maculosa* plants colonizing shaly slopes along interstate highways (I81 in Lebanon Co. and I283 in Lancaster Co., Pennsylvania). To allow more sites to be surveyed, this rather time-consuming, scratch-and-search collecting method (Slater and Baranowski 1978: 9) was abandoned. Instead, a small shovel was used to scoop soil (about 0.25 ft$^3$) beneath spotted knapweed into a plastic bag. In the laboratory, specimens of *M. sabulicola* could be obtained by processing soil samples in a Berlese funnel, but its presence at a site could be determined more easily by sorting soil dumped into a white enamel tray. The bugs typically became concentrated in the bottom of the plastic bag and were collected when the last batch of soil was placed in the tray.

Populations were readily detected by this method, and it was soon apparent that this immigrant rhyparochromine is common in eastern Pennslyvania. Fewer than five of the nearly 30 soil samples taken were negative for *M. sabulicola.* West of the Allegheny mountains, however, populations were more difficult to locate.

*Megalonotus sabulicola* was found consistently under *C. maculosa.* Soil nearly always could be taken beneath pure colonies owing to the plant's allelopathic effects on nearby vegetation (Fletcher and Renney 1963). Bugs were absent in the few soil samples taken under other composites, e.g. *Eupatorium* and *Solidago* spp. Nymphs and adults were found not only under spotted knapweed in sparse colonies on shaly highway embankments but under plants growing in other disturbed situations: in wet clayey soil, in vacant lots and at the edge of roads, in thick sod of pastures, in gravelly soil at the edge of parking lots, in gravel pits and stone quarries, and in fine sooty and sandy ballast along railroads.

As Slater and Sweet (1958) and Sweet (1964) noted, *M. sabulicola* is restricted to the litter layer near *Centaurea* plants. During the distribution survey, no adults were taken by sweeping spotted knapweed. Adults, probably dispersing individuals, sometimes occur on other vegetation; for example, they have been collected on strawberries (Scudder 1961) and corn (Hoebeke 1977). On two occasions at Ithaca, New York, adults were collected on alfalfa, *Medicago sativa* L.; at Elizabethtown, Pennsylvania, an adult was beaten from a small Swiss mountain pine, *Pinus mugo* Turra.

During 1987–88, a population of *M. sabulicola* associated with spotted knapweed growing at the edge of a gravel parking lot along Rt. 934 near its junction with Rt. 22 (Lebanon Co., Pa.) was monitored more frequently than other sites but only at irregular intervals. Based on a composite of observations made in Pennsylvania and other mid-Atlantic states, phenology conforms generally with that reported for bivoltine populations of the bug in New England (Sweet 1964).

This lygaeid overwinters in the adult stage. Overwintering individuals were found in litter and soil taken beneath spotted knapweed from mid-October to early December and during late March to early May. In Pennsylvania, first and second instars occurred in early June, with first generation adults appearing by early July. Early instars of a second generation were not collected, but fourth and fifth instars were found during mid-August. They were present until late September and were found in southern New Jersey with a few second and third instars in early October.

At Canaan in Connecticut's northern highlands, Sweet (1964) found that overwintered adults oviposited from May to early June, the tacklike eggs attached to litter beneath hosts, sand, or plant fuzz. In early June, Connecticut populations consisted mainly of first and second instars; by late June, a few fifth instars were present with larger numbers of instars II–IV. First generation adults appeared during July, and first instars of a second generation were observed in late July. The two generations overlapped considerably; some first generation females continued to oviposit into August. Second generation adults entered a reproductive diapause. By late September, Sweet found that the Canaan population consisted of 80% adults, 19% fifth instars, and 1% fourth instars. By mid-October, adults made up 95% of the population. Compared to Canaan, phenology at Storrs in eastern Connecticut was advanced by about three weeks (Sweet 1964).

## EFFECTS ON SPOTTED KNAPWEED POPULATIONS

*Centaurea maculosa* is a biennial or short-lived perennial (Watson and Renney 1974, Maddox 1979) belonging to the composite subfamily Cynaroideae, which includes the well-known thistle genera *Carduus* and *Cir-*

*sium.* In some recent schemes of higher classification, *Centaurea* is placed in the tribe Cardueae, subtribe Centaureinae (Dittrich 1977, Zwölfer 1988). Spotted knapweed is thought to have been introduced to North America in alfalfa seed that originated in continental Europe or Asia Minor-Turkmenistan (Maddox 1979). Although this invasive plant is a pioneer species useful in erosion control, it poses a serious threat to western rangelands, where millions of acres are infested (Maddox 1979). It also is pestiferous in rangelands of British Columbia (Strang et al. 1979) and is listed as a noxious weed in Manitoba (Watson and Renney 1974). Well established in Ontario, Quebec, and the Canadian maritime provinces (Watson and Renney 1974), spotted knapweed generally infests the eastern United States except for the Deep South (USDA 1971).

Since 1970, several seed-and root-feeding insects have been evaluated and released for their biocontrol potential against spotted knapweed (Harris and Myers 1981, Müller et al. 1988). *Megalonotus sabulicola,* an inadvertent introduction, should be included among the seed-destroying insects associated with *C. maculosa.* Sweet (1960, 1964) discussed the ecological role of seed bugs belonging to the large lygaeid subfamily Rhyparochrominae. Seed destruction not only results from the piercing of seed coats but, according to Sweet (1964), probably from subsequent invasion by pathogenic fungi. Eyles (1964) also discussed seed-feeding behavior of rhyparochromines, including destruction of the embryo.

Habits of *M. sabulicola* have not been studied in western North America, but the identification of *Centaurea cyanus* seeds as a preferred food source in New England (Slater and Sweet 1958, Sweet 1964) gave more meaning to the seemingly accidental occurrence of the lygaeid in Oregon pea fields. In reporting three specimens from the Willamette Valley, Larson and Hinman (1932) remarked that the crop was infested by weeds, mainly cornflower, *C. cyanus,* and Canada thistle, *Cirsium arvense* (L.) Scop. The lygaeid probably was feeding on *C. cyanus* seeds in the litter layer of pea fields in Oregon and may now be established in areas of western rangeland infested with *C. maculosa.*

In the East, *M. sabulicola,* as a seed feeder closely associated with spotted knapweed, should be considered beneficial. Prolific seed production, however, is characteristic of *C. maculosa,* with as many as 40,000 seeds/m$^2$ capable of being produced (Watson and Renney 1974). Some of the insects released in biocontrol efforts against *Centaurea* spp. significantly curtail seed production but have failed to limit plant density (Harris and Myers 1981, Müller et al. 1988). *Megalonotus sabulicola* may also destroy large numbers of seeds, but its effects on plant reproduction must be minimal. Even in areas of Pennsylvania where this accidentally introduced seed predator has become abundant, stands of spotted knapweed continue to flourish.

## RECOGNITION FEATURES

*Megalonotus sabulicola* (Fig. 2) may be placed in the large subfamily Rhyparochrominae by having the suture between abdominal sterna 4 and 5 curving anteriorly, not meeting the lateral margin. Adults are hairy, medium-sized, usually macropterous lygaeids with hemelytra a mottled brown-testaceous, somewhat contrasting with the dull piceous head, pronotum, and scutellum. Adults can be additionally characterized as 3.80–5.40 mm long (New York and Pennsylvania specimens), somewhat elongate, broadest across posterior third of hemelytra; head relatively short, declivent, rostrum extending to bases of mesocoxae; pronotum trapeziform, punctate, separated into anterior and raised posterior lobes, anterior margin lacking ringlike collar, lateral margin distinctly carinate; scutellum punctate, longer than wide; long, erect, bristlelike setae on head, pronotum, and scutellum

Fig. 2. *Megalonotus sabulicola*, adult habitus; scale bar = 1.0 mm.

(those on head and scutellum about 0.25 mm long) intermixed with finer, paler, more appressed setae; forefemur black, incrassate with prominent tooth ventrally on apical third; meso- and metafemora black apically, yellowish basally; tibiae yellowish, with stout dark spines.

The antennal and tibial characters Southwood (1963) used to separate *M. sabulicola* from *M. chiragra*—antennal segment II and hind tibiae in *sabulicola* almost wholly yellow and antennal segment III with broad, central, yellow band—do not always hold true for eastern U.S. specimens. Sweet (1964) noted that in certain New England populations antennae and hind tibiae showed the dark *chiragra*-like color patterns. Specimens (ca. 120) collected in this study, however, always have antennal segment II and the hind tibiae yellow or pale yellowish brown, whereas antennal segment III varies from mostly yellow to entirely black.

Fifth-instar nymphs can be keyed in Sweet and Slater (1961); nymphal characters distinguishing members of the tribe Megalonotini are discussed by Slater and Sweet (1961). Slater and Sweet (1958) described instars III–V.

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# AN EXCEPTIONAL FOSSIL AMBER COLLECTION ACQUIRED BY THE SMITHSONIAN INSTITUTION

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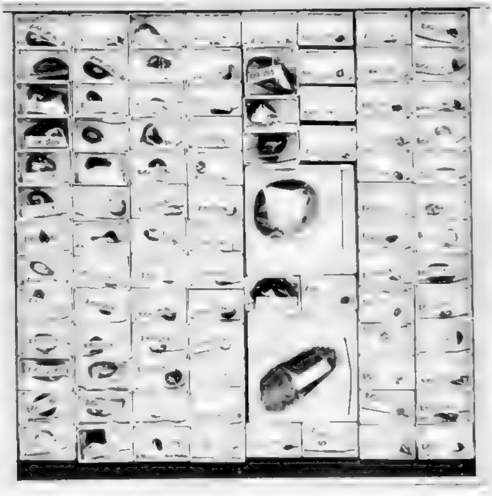
*Abstract.*—One of the largest collections of fossil arthropods preserved in amber from the Dominican Republic has been acquired by the Smithsonian Institution's Department of Entomology. The collection, known as the Brodzinsky/Lopez-Penha Collection, comprises over 5000 amber samples estimated between 20 and 30 million years old. Each sample contains from 1 to over 65 specimens of arthropods representing 22 insect orders as well as several arachnids and myriapods and some plant material.

*Key Words:* amber, fossil insects, fossil arthropods

The Department of Entomology of the National Museum of Natural History, with the support of the Smithsonian Institution's Collection Acquisition Program, has recently acquired one of the largest collections of fossil organisms in Dominican amber. The collection was amassed by Jacob Brodzinsky and Marianela Lopez-Penha Brodzinsky of Santo Domingo, Dominican Republic. The Brodzinsky/Lopez-Penha Collection comprises over 5000 amber samples, with each piece containing from one to approximately 65 fossilized organisms (Figs. 3, 4). Although a tally has not been completed, a conservative estimate would place the number of insect inclusions in this collection at well over 10,000.

For several millennia humans have been fascinated by amber, not only by its beauty but also for its use in amulets and medicines. Its formation is still only partially understood, although its general properties are well known. Amber is a fossilized, highly polymerized resin and, consequently, of vegetable origin. It requires millions of years to form, and exposure to the catalytic action of salt water probably is needed to harden and polymerize it. It has a hardness varying between 1 and 3, a specific gravity between 1 and 1.3, and a melting point ranging from 120°C to 400°C (usually 300°C to 400°C for Dominican amber). These characteristics distinguish amber from the more recent copals and most of the plastic imitations (Larsson 1978, Poinar 1985). Amber is not a stable substance but, instead, can gradually oxidize, dry out, and crack once removed from its natural ground or seabed deposit and polished. Consequently, one of the clues to preservation is storing the samples in containers with minimal exposure to air but, as is true for pearls, with occasional handling to provide a protective oil film. Dominican amber is frequently clear and honey colored although it can range in color from nearly transparent to jet black through yellow, red, blue, and green (Baroni-Urbani and Saunders 1980). Amber deposits around the world vary greatly in age, in degree of fossilization, as well as in plant origin. In the Dominican Republic this material is found as secondary deposits in mid-Tertiary sandstone marine silts which range between 20 to 30 million years in age. The



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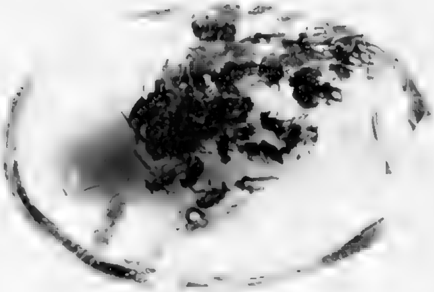

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Figs. 1–5. Brodzinsky/Lopez-Penha Amber Collection. 1. Standard USNM drawer with trays containing individual samples. 2. Detail of sample tray showing label data and samples enclosed in zip-lock plastic bags. 3. Sample 10747, containing approximately 50 specimens of mostly Dolichopodidae (4 mm). 4. Sample 10755, containing approximately 65 specimens of Dolichopodidae (4 mm). 5. Sample containing a flower petal from the tree (*Hymenaea*) and probable source of the original resin, and a mycetophilid fly. (Scale length in parentheses.)

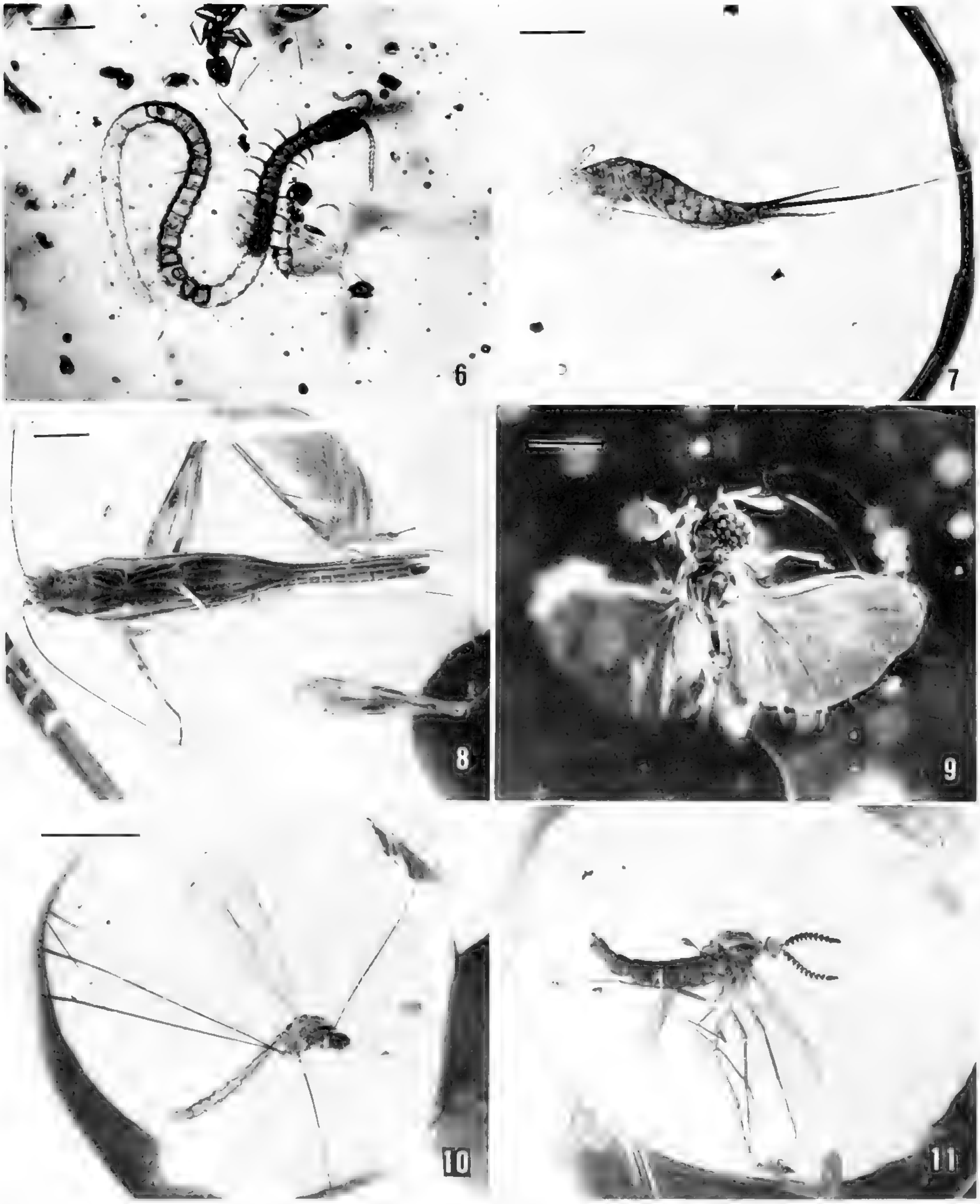
primary plant source of Dominican amber is believed to be *Hymenaea*, an extant genus of Leguminosae currently represented by one African species and about two dozen neotropical species (Poinar 1985).

The scientific value of amber lies primarily in the inclusions it often contains; frequently these inclusions are insects. The preservation of some specimens, in which the object itself is often intact and is not merely represented by an impression or some mineral replacement, can be so perfect to appear unreal considering their antiquity.This has prompted some scientists to liken such samples as "windows to the past." The natural fixatives in some plant resins have preserved tissues so well that sectioning has revealed such minute anatomical details as nuclei and other cellular inclusions (Poinar and Hess 1982).

Amber from the Dominican Republic was first reported by Christopher Columbus after his second voyage between September 1492 and March 1496 (Hale 1891). No further mention of this material has been noted until the early twentieth century. Sanderson and Farr (1960) visited one of the major Dominican deposits and reported on the diverse representation of fossil insects. Schlee and Glöckner (1978) lists 28 arthropod orders represented in Dominican amber in their general review of "Bernstein." Only two years later, this inventory was updated by Baroni-Urbani and Saunders (1980). Thus far the Dominican Republic is the only locality in the West Indies where amber has been found.

My first experience with Dominican amber, other than examining occasional museum samples, occurred during a fieldtrip in 1973. After visiting several amber shops in Santo Domingo, I became duly impressed at the amount of fossil material being sold as jewelry and, for all purposes, lost to science. It was apparent that a major source of knowledge on the Tertiary insect fauna was disappearing without adequate sampling or documentation. Subsequently, I routinely urged every amber dealer I occasionally met to allow interested biologists to examine and perhaps purchase the best preserved fossils before these were sold on the general market. In 1977 I had the good fortune of meeting Mr. Jacob Brodzinsky and his wife, who like so many previous amber dealers, visited our entomology department with the desire to have their fossil insects identified. The Brodzinsky's were not only sympathetic to my plea to allow entomologists to examine their fossil material, but they also began in earnest to amass a sizeable collection of their own. A year later Brodzinsky met Dr. Robert Woodruff of the Florida Department of Agriculture, an entomologist also interested in amber fossils. Together with Brodzinsky, Woodruff began to register this material as a means of permanently documenting the identification and final deposition of the more valuable specimens. This registry has now approached 12,000 samples. A major portion of this material, all collected after 1977 and containing some of the rarest and best preserved fossil specimens, was set aside as the Brodzinsky/Lopez-Penha Collection.

Jacob Brodzinsky has estimated that approximately five percent of the amber samples discovered contain insect remains. This estimate agrees with the overall inclusion percentage others have expressed (Baroni-Urbani and Saunders 1980). Brodzinsky also has reported (in litt.) that on at least two occasions he has encountered between 12 and 20 specimens for each pound of amber examined. The overwhelming majority of these inclusions either represent fragmentary remains or are so poorly positioned that identification, even to the family level, may be impossible. As an example of the culling process that must be accomplished, Brodzinsky estimates that he has examined approximately 140,000 amber samples containing inclusions since 1977. From this considerable material, he selected only the finest examples for his personal collection and the smaller collections which he sold



Figs. 6–11. Brodzinsky/Lopez-Penha Amber Collection. 6, Sample 9366, centipede (Geophilidae?) and Formicidae (1 mm). 7, sample 9452, Archaeognatha (2 mm). 8, sample 8873, Gryllidae, Trigonidiinae, *Annaxipha* sp. (2 mm). 9, Sample 5204, Strepsiptera (0.5 mm). 10, Sample 10939, Tipulidae, *Trentepohlia* sp. (2 mm). 11, Sample 10668, Keroplatidae (Mycetophilidae, sensu latu). (Scale length in parentheses.)

piecemeal to various scientific institutions, including the Smithsonian Institution. A cursory inventory of the Brodzinsky/Lopez-Penha Collection reveals the high degree of his selection and desire to assemble a truly representative sample. Included in the over 5000 samples are 22 of the 26 generally recognized insect orders. The four orders not represented are Protura, Anoplura, Mallophaga, and Mecoptera. Ants are among the most common insects trapped by resin flows and subsequently entombed in amber. Realizing this, Brodinsky did not "load" his collection with this one family (less than 300 samples contain Formicidae), but instead he attempted to diversify the collection as much as possible. Among some of the rarer specimens are: Embioptera (7 examples), Ephemeroptera (9), Neuroptera (6, including one intact Hemerobiidae and one Sialidae), Plecoptera (1), Siphonaptera (1), Strepsiptera (3), Zoraptera (1), and many rare Coleoptera, Diptera, Homoptera, Hymenoptera, Lepidoptera, and Trichoptera. Other rare organisms include preserved flowers (Fig. 5) of the tree (*Hymenaea*) believed to be the primary source of the amber, centipedes (Fig. 6), millipeds, isopods, pseudoscorpions, mites, and one small bird feather. Among the more unusual samples are such specimens as copulating pairs of Diptera (Ceratopogonidae and Chironomidae) and a micropezid fly with a colony of phoretic mites on the ovipositor. George Poinar of the University of California, and one of the appraisers of the collection, has estimated (in litt.) that approximately 20% of the collection consists of new species or potential holotypic material. The absence of some insect groups is also of some interest. Although aphids are relatively common in Baltic amber, none have yet turned up in the large sample examined by Brodzinsky.

The Brodzinsky/Lopez-Penha Collection is now stored in standard insect drawers (Fig. 1) within airtight steel cabinets. Each sample is enclosed within a small zip-locked plastic bag which is then placed in individual trays arranged in numerical sequence according to the Woodruff registry number (Fig. 2). A permanent register number is attached to the tray with a duplicate label included inside the bag with the sample. The fossil contents are currently in the process of being inventoried and recorded in dBase III for rapid access.

Future acquisition and research on Dominican amber could become more difficult. As recently reported (Anonymous 1988) the government of the Dominican Republic has now taken more stringent steps to regulate the export of amber fossils. Decree number 288-87 states that the amber mines are government property under law. Exportation of amber with plant or animal fossils is prohibited unless accompanied by official permission granted by the Museo Nacional de Historia Natural, Santo Domingo.

Jacob and Marianela Brodzinsky are still very much involved with their Dominican amber enterprise. It is hoped they will continue to discover new and exciting fossils and bring these to the attention of interested investigators for some time to come. For their concern of this scientifically priceless heritage, all biologists should be grateful.

## ACKNOWLEDGMENTS

I wish to thank Jacob Brodzinsky and his wife Marianela Lopez-Penha for their dedicated efforts over the years in assembling an excellent representation of Dominican amber fossils. Our Department is grateful for the support of the Collection Acquisition Program of the Smithsonian Institution which provided funds for the purchase of this collection. I am also thankful to George Poinar, Jr. of the University of California, Berkeley, John Tkach of Bozeman, Montana, and Robert Woodruff, Florida Department of Agriculture and Consumer Services for their helpful support. Assistance with identifications was provided by Wayne Mathis, Smithsonian Institution, David Nickle, U.S. Department of Agriculture.

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# REDESCRIPTION OF *CX. CORNIGER* THEOBALD AND ELEVATION OF *CULEX* (*CULEX*) *LACTATOR* DYAR AND KNAB FROM SYNONYMY BASED ON SPECIMENS FROM CENTRAL AMERICA (DIPTERA: CULICIDAE)

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*Abstract.*—*Culex* (*Culex*) *lactator* Dyar and Knab is resurrected from synonymy with *Culex* (*Culex*) *corniger* Theobald on the basis of morphological differences in the adult, male genitalia, and fourth-instar larva. Both species are redescribed and illustrated. *Culex lactator* has been collected from Mexico to northern South America at elevations from sea level to 1500 m. Most larval habitats were in direct contact with the ground, in contrast to the container habitats of *Cx. corniger.*

*Key Words:* Diptera, Culicidae, *Culex, lactator, corniger, coronator, restuans,* taxonomy, canonical variable, discriminant analysis, Central America

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*Culex* (*Culex*) *corniger* Theobald is known from the Caribbean and Mexico to Uruguay (Knight and Stone 1977). It is easily recognized by the unusual form of the larva and the ornamentation on the mesonotum of the adult. We first saw evidence of two forms of the species in Honduras during extensive collecting in many parts of the country. Study of this and other material in the collections of the United States National Museum resulted in the discovery of differences in all stages of two forms of this species in Central America. One form resembled *Cx. corniger* from its type locality in Pará, Brazil, and the other resembled the lectotype (Stone and Knight 1957) of the junior synonym, *Culex lactator* Dyar and Knab from Rincon Antonio, Oaxaca, Mexico. We therefore elevate *Cx. lactator* from synonymy to species status.

## METHODS

First, detailed morphological examinations were made of specimens from Mexico to Costa Rica. Once these studies produced clear means of identification, specimens were examined from other parts of the Neotropics to understand the distribution of *Cx. lactator.* Except for material from the type locality, no material of *Cx. corniger* from outside of Central America was examined.

Morphological terminology is defined in Harbach and Knight (1980) with modified terms for the male genitalia taken from Harbach et al. (1983). Abbreviations used in figures were taken from the same references. Color designations were based on color printing process, as outlined in Kueppers (1982) and used previously for mosquitoes by Strickman (1988). The system describes colors as combinations of three of the following hues: Black (B), cyan (C; a deep sky blue), magenta (M; a deep reddish purple), and yellow (Y). Each component of the color mix is expressed as a percentage of the coverage of a white page (e.g. $B_{10}M_{20}C_{99}$ is a sky blue color). To describe a color, an area of the specimen and the appropriate color chart were illuminated with light from tungsten bulbs receiving five volts of electricity. The color on the specimen was then matched by eye to the nearest color on the chart, taking care to examine each color of the chart surrounded by a neutral gray mask. For light yellow, the color charts did not offer enough resolution to describe color observed by eye. In these cases, the color was described as "yellowish." The use of this color system was not intended to replace qualitative color descriptions; instead, it was meant to provide objective measurements of a species which would act as standards for the authors' perception of color.

Material examined was from the United States National Museum. Abbreviations are ♀ for female adult, ♂ for male adult, ♂G for male genitalia, P for pupa, and L for larva.

Canonical discriminant analyses of larvae and pupae were performed in an effort to use combinations of characters to provide better separation than individual characters. The CANDISC procedure in SAS software (SAS Institute Inc., Carey, NC) was chosen for the analyses because of its simplicity and availability. This procedure finds linear combinations of quantitative characters that best separate known classes. Standardized coefficients enabled ranking importance of characters regardless of numerical size. Raw coefficients were used to produce formulas involving characters that were measured on a specimen. The sum of products of characters and coefficients resulted in a single value, the canonical variable, used to separate species. The sensitivity and accuracy, as defined by Griner et al. (1981), of this method of identification were evaluated by calculating the canonical variable value for each specimen, then counting the number of correct identifications.

## TAXONOMY

### *Culex* (*Culex*) *corniger* Theobald

*Culex corniger* Theobald, 1903: 173, Fig. 93 (Pará, Brazil, male type, female); Belkin, 1968: 15 (lectotype designation).

*Culex basilicus* Dyar and Knab, 1906b: 169 (Arima, Trinidad, female).

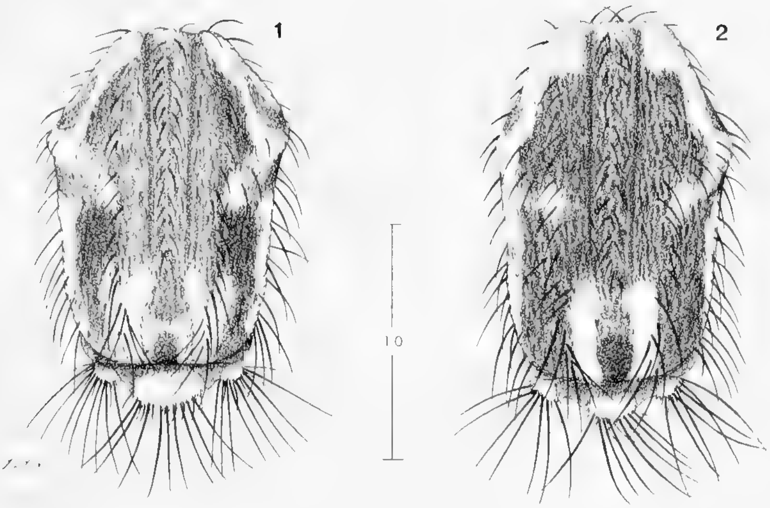
*Culex hassardii* Grabham, 1906: 167 (Newcastle, Jamaica, male).

*Culex subfuscus* Theobald, 1907: 403 (Moneague, Jamaica, male).

*Culex lactator* var. *loquaculus* Dyar and Knab, 1909: 254 (Corozal, Panama Canal Zone, female).

*Culex rigidus* Senevet and Abonnenc, 1939: 68 (Saut-Tigre, French Guiana, male).

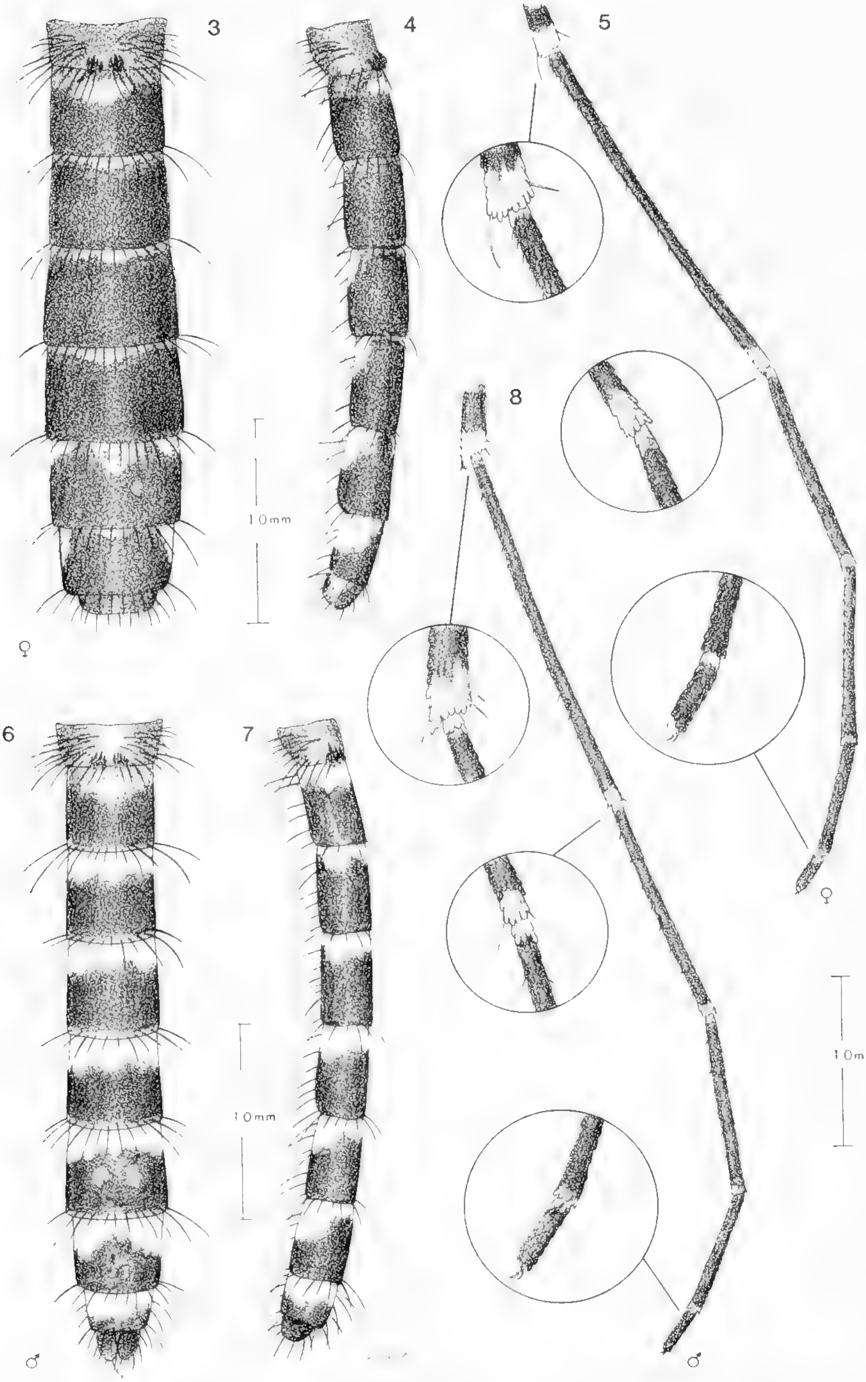
Female (Figs. 2, 3–5).—*Head:* Proboscis black with white band from 0.5 to 0.75 length; band incomplete on dorsal surface, separated by as little as single row of dark scales on either side of channel. Maxillary palpus and clypeus entirely dark. Antennal pedicel without scales, yellowish; first and base of second flagellomere yellowish; remainder black. Vertex with erect narrow scales light medially, dark brown laterally, but sometimes few brown ones; decumbent scales yellowish and white, white on ocular line. Broad white scales on postgena. *Thorax:* Mesonotum as in Fig. 2; light scales yellowish to almost white; background scales dark brown ($B_{90}Y_{90}M_{80}$); bare areas laterad of lateral and posterior scutal fossal and acrostichal scales; bare area at posterior of prescutellar area. Scutellar scales pure white. Lateral of thorax similar to *Cx. lactator* (Fig. 18). Antepronotum with setae over most of surface, narrow dingy white scales on ventral portion. Postpronotum with setae on posterodorsal margin, narrow pale scales along dorsal margin. Proepimeron bare. Proepisternum with numerous setae and sparse to numerous small white scales. Low-



Figs. 1, 2. Dorsal view of mesonotum and scutellum of females from Honduras (WRBU Acc. 1179). 1, *Cx. lactator* (coll. HONC 241-100). 2, *Cx. corniger* (coll. HONC 230-108).

er mesokatepisternum with 1–6 setae and group of dingy white, medium broad scales; upper mesokatepisternum with row of setae and group of dingy-white moderately broad scales; prealar knob with numerous setae and small, translucent scales; pigmentation of integument between scale patches and above middle scale patch conspicuously darker than remainder of sclerite; hypostigmal and postspiracular areas bare, with darkly pigmented integument. Mesanepimeron with up to 4 lower setae, 8 upper setae, and anterior patch of moderately broad, pure white scales; dark pigmentation of integument as on mesokatepisternum. Paratergite without scales. Pattern of pigmentation on integument of pleuron in 2 bands separated by white scale patches. *Legs:* Dark scales similar in color to proboscis. Forecoxa with small patch of light scales dorsally, light ventrally and posteriorly; apical fringe of light scales around segment. Foretibia for most of its length dark dorsally, light ventrally; apical band of light scales around segment. Foretarsus with basal and apical light bands on tarsomeres 1–4, light scales on basal portion of tarsomere 5; bands sometimes very narrow. Midcoxa with translucent scales, light integument. Midfemur dark dorsally and anteriorly, light ventrally and posteriorly; light scales surround segment at base; dark scales surround segment near apex; apical fringe of light scales. Midtibia dark with light scales ventrally and apical band of light scales. Midtarsus similar to foretarsus. Hindcoxa with translucent scales and light integument. Hindfemur dark dorsally; dark area progressively wider apically; dark scales surround segment near apex, light scales surround segment at base; border between light and dark scales near apex roughly a right angle; apical fringe of light scales. Hindtibia dark with light scales ventrally and light apical band 5–6 scales wide. Hindtarsus as in Fig. 5. *Wings:* Scales on costa, subcosta, radius, and bases of other veins brown ($B_{99}Y_{10}M_{30}$) and overlapping. *Abdomen:* Terga as in Figs. 3, 4; basal bands slightly yellowish, whiter laterally; dark scales dark brown ($B_{99}Y_{20}M_{40}$). Sterna V-VII each with complete posterior band of dark scales.

Male adult (Figs. 6–8).—*Head:* Proboscis dark brown with white band surrounding false joint; band complete but on dorsal surface dark scales intrude from apex. Maxil-



Figs. 3–8. Adult *Cx. corniger* from Honduras (WRBU Acc. 1179; ♀ HONC 230-14; ♂ HONC 230-12). Scale bars do not apply to magnified insets. 3, Female abdomen, dorsal view. 4, Female abdomen, lateral view. 5, Female hindtarsus and apex of hindtibia, anterior view. 6, Male abdomen, dorsal view. 7, Male abdomen, lateral view. 8, Male hindtarsus and apex of hindtibia, anterior view.

lary palpus 1.4 longer than proboscis; dark brown dorsally with light scales on apical 0.5 of palpomere 5 and middle of palpomere 3, narrow light bands at base of 5, base and apex of 3 and 4; ventrally, bright white patches of broad scales on base of 5, just beyond middle and at base of 4; light scales at middle and base of 3. *Thorax:* Light scales usually not as extensively developed on mesonotum as in female. Antepronotum with longer, wider scales than on female. *Legs:* Hindtarsus as in Fig. 8. *Abdomen:* As in Figs. 6, 7; light scales more extensive than in female.

Male genitalia (Figs. 9–13).—*Ninth tergum* (Fig. 13): Shallowly cleft between setose lobes; setae in 3–5 irregular rows, each seta on a small tubercle; integument of lobes aculeate. *Proctiger* (Fig. 12): Basal lateral arm nearly constant in width to tip; base with small mesal, rounded projection; acetabulum prominent; cercal setae 1–5 (mode = 3). *Lateral plate* (Fig. 10): Dorsal process small or absent; lateral lobe prominent, arising from lateral ridge, curving posteriorly along ventral margin, ending in concave rugulose lobe; denticles directed dorsally, tightly packed; individual denticles slightly curved dorsally; ventral arm curved and papery with mesal thickened ridge; dorsal arm short, reaching to or slightly beyond bases of denticles, with pointed or rounded tip. Viewed dorsally in whole mount, lateral lobe and ventral arm form 2 or 3 large lobes with the denticles at their common base. *Gonocoxopodite* (Fig. 9): Surface opposite subapical lobe flattened; integument aculeate, subapical lobe protruded as a tab; seta *a* a slender rod, gently curved at tip, with prominent sclerotized socket at base; seta *b* stouter than *a,* curved and usually recurved at tip, with prominent sclerotized socket at base; seta *c* similar to seta *a*; seta *d–f* small and hairlike; seta *g* on tubercle, foliform, usually with weak striations; seta *h* finer than *a* or *b,* socket much less developed; gonostylus with tip minutely divided, claw trough-shaped.

Pupa (Figs. 14, 15; Table 1).—*Cephalothorax:* Trumpet, median keel, scutum, metanotum, median portions of metathoracic wing, sometimes dorsal portion of mesothoracic wing darker than other areas of cuticle; trumpet dark anteriorly. Trumpet in shape of flattened cone. *Abdomen:* Anteromedian edge of terga I, III, IV, and sometimes terga II, V–VIII, sternum III, and sometimes sterna II–VIII darkly pigmented; lighter pigmentation on median portions of terga, sterna I–III, and sometimes sterna IV–VII; pigmentation progressively light posteriorly from III; surface of tergum I reticulate at 200x; surfaces of terga, sterna II–VIII, genital lobes minutely spiculate; posterior of sternum II with fine spicules; distal 0.5–0.67 of outer margin of paddle minutely spiculate; spot of pigmentation on anterior portion of buttress light, dark, or absent; seta 2-P sometimes absent, very small when present. *Chaetotaxy:* As in Table 1; Figs. 14, 15.

Larva (Fig. 16, Tables 2, 5).—*Head:* More pigmented around mouthparts, on lateralia and collar; antenna slightly darker from seta 1 to tip; mean antennal tuft ratio (distance from antennal base to seta 1-A divided by antenna length) 0.51 (SD = 0.04, min = 0.43, max = 0.62, n = 34). *Thorax:* Integument coarsely spiculate, coarsest on mesothorax but clearly visible on all segments at 40x; support plate of setae 9–12 with minute spines on prothorax, large spines on meso- and metathorax. *Abdomen:* Spiculation finer than on thorax; spicules not visible on all surfaces at 100×; coarse spicules on posterior edge of segment X progressively finer ventrad. *Siphon:* Heavily pigmented on acus, base, spiracular apparatus, spiracular apodeme, and around distal portion of siphon; small projection sometimes visible on basal side of ring formed by spiracular opening of spiracular apodeme; mean spiracular apodeme ratio (length of spiracular apodeme divided by dorsal length of siphon) 0.45 (SD = 0.02, min = 0.42, max = 0.50, n = 33); modal number of

Figs. 9–15. Male genitalia and pupal exuviae of *Cx. corniger*. Drawn from Guatemalan specimen GUA 17-11 (phallosome), Honduran specimen HONC 230-14, WRBU Acc. 1179 (dissected genitalia), and Nicaraguan specimen NI 45-16 (pupa). 9, Gonocoxopodite, mesal view. 10, Lateral plate, lateral and mesal views. 11, Phallosome, dorsal view. 12, Proctiger, dorsal view. 13, Ninth tergal lobes, dorsal view. 14, Pupal cephalothorax (CT), anterior lateral quadrant. 15, Metathoracic wings and abdomen (P = paddle; each magnified inset is 0.05 mm across).

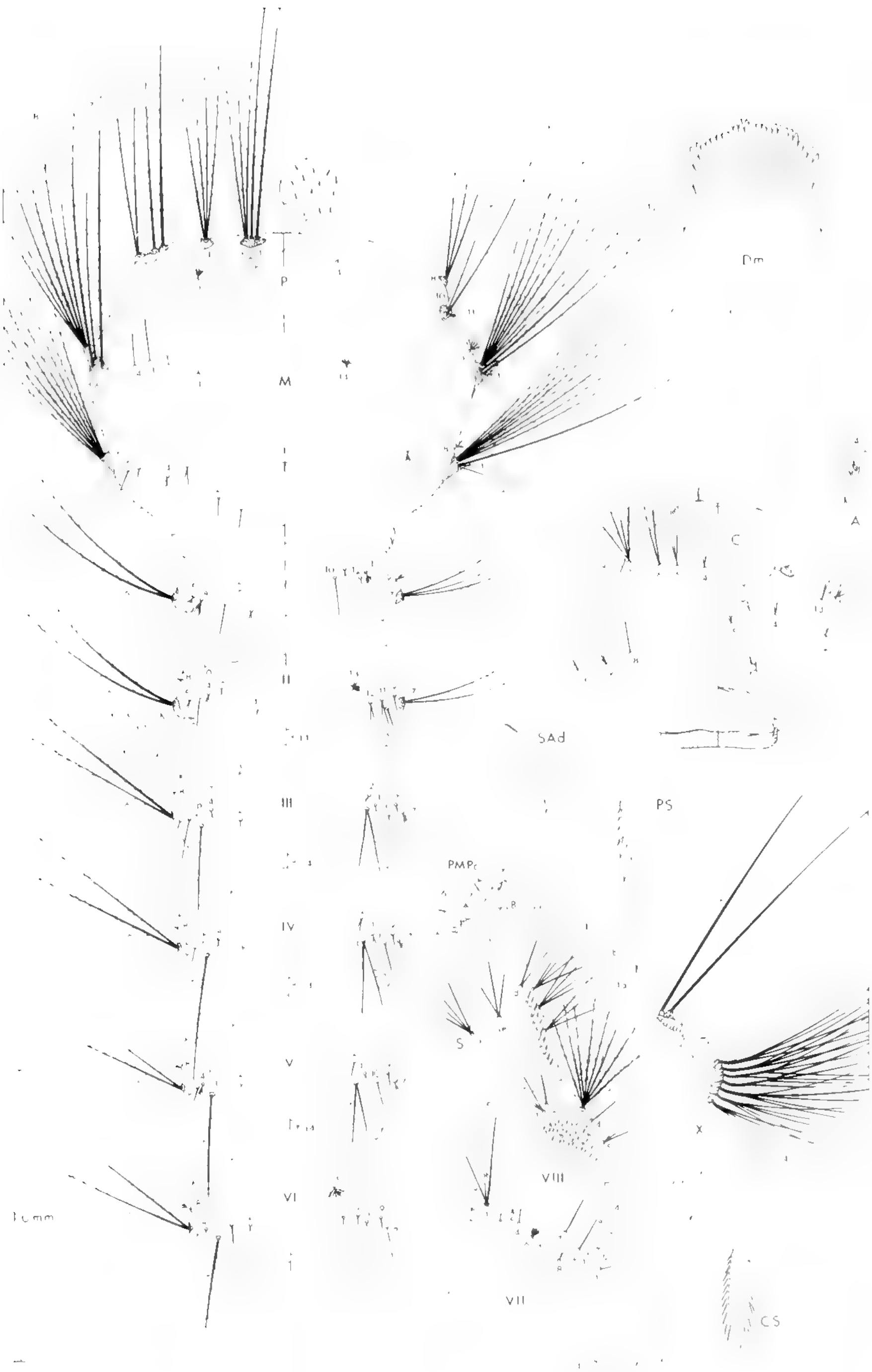


Fig. 16. Larva of *Cx. corniger,* Nicaraguan specimen NI 45-1. Scale does not apply to enlargements of dorsomentum, spiracular apodeme, pecten spine, or comb scale; each magnified inset of spiculation is 0.07 mm across. (A = antenna; C = head; CS = comb scale; Dm = dorsomentum; M = mesothorax; P = prothorax; PMPc = posterior median process; PS = pecten spine; S = siphon; SAd = spiracular apodeme; T = metathorax.)

Table 1. Number of branches of pupal setae of *Culex* (*Culex*) *corniger.* Based on counts made on 10 specimens from 10 collections in Mexico, Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica.

| Seta No. | CT | Abdominal Segments | | | | | | | | | Paddle P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | |
| 0 | — | — | 1[a] | 1 | 1 | 1, 2 (1) | 1 | 1 | 1 | — | — |
| 1 | 1, 2 (1) | 7–12 (9) | 7–12 (10) | 2–7 (2) | 2–5 (2) | 1–3 (2) | 1, 2 (1) | 1, 2 (1) | — | 1 | 1, 2 (1) |
| 2 | 1, 2 (2) | 1, 2 (2) | 1 | 1 | 1 | 1 | 1 | 1 | — | — | 1 |
| 3 | 1 | 2 | 2 | 2 | 3–5 (4) | 1–4 (1) | 1, 2 (2) | 1 | — | — | — |
| 4 | 2–4 (2) | 2–5 (4) | 2, 3 (2) | 4, 5 (5) | 2, 3 (2) | 2–4 (3) | 1, 2 (2) | 1, 2 (1) | 1, 2 (1) | — | — |
| 5 | 2–4 (3) | 2–5 (5) | 1, 2 (1) | 1–3 (2) | 1 | 1 | 1 | 1 | — | — | — |
| 6 | 1, 2(2) | 1 | 1 | 1 | 1 | 1 | 1 | 2–5 (3) | — | — | — |
| 7 | 2 | 1–3 (2) | 1–4 (2) | 3–5 (4) | 2–4 (2) | 2–6 (4) | 1 | 1 | — | — | — |
| 8 | 1 | — | 1 | 2–4 (3) | 2–4 (3) | 2–5 (3) | 2, 3 (3) | 1–3 (2) | — | — | — |
| 9 | 1, 2(2) | 1–3 (1) | 1 | 1 | 1 | 1 | 1 | 2, 3 (2) | 4–7 (6) | — | — |
| 10 | 3–8 (4) | — | — | 1, 2 (1) | 1, 2 (1) | 1 | 1 | 1 | — | — | — |
| 11 | 2 | — | — | 1 | 1 | 1, 2 (1) | 1 | 1 | — | — | — |
| 12 | 1, 2(2) | — | — | — | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — | — | — | — | — |
| 14 | — | — | — | 1 | 1 | 1 | 1 | 1 | 1, 2 (1) | — | — |

[a] Range (mode).

siphon tufts 6 (min = 5, max = 6, n = 33); other quantitative measurements in Table 5. *Chaetotaxy:* As in Table 2, Fig. 16.

Diagnosis.—*Culex corniger* can be distinguished from other members of the subgenus in Central America north of Panama by the following features: *Adult:* Proboscis with light band (though not always completely surrounding proboscis); characteristic mesonotal pattern (Fig. 2); basal and apical light bands on tarsomeres well defined and continuing beyond base of tarsus 3. In female, basal light bands of abdominal terga II–VII not connected laterally to lateral light spots on at least one segment. *Male genitalia:* Ninth tergum shallowly cleft with numerous setae on lobes; lobes connected by thin strap of cuticle; lateral plate of characteristic form (Figs. 10, 11); dorsal process poorly developed; lateral lobe well developed; subapical lobe with setae *a, b, c, d–f, g* (foliform), and *h* present; gonostylus narrowed beyond basal 0.3. *Larva:* Antenna not markedly tapered in apical portion; tuft (seta 1-A) with 3 or fewer branches; linear combination of characters (see Discussion) including (in order of importance) saddle index, branches of seta 4-C, siphon index, branches of seta 7-C, ratio of distance to seta 1a-S (from base of siphon) to siphon length, number of pecten teeth, and pecten row length index.

Remarks on types and original descriptions.—We were able to examine type specimens for three of the five remaining synonyms for *Cx. corniger. Culex basilicus* Dyar and Knab (from Trinidad, 1906b) (♀ lectotype designated by Stone and Knight 1957), *Cx. hassardii* Grabham (from Jamaica, 1906) (♂ lectotype designated by Belkin et al. 1970) and *Cx. lactator* var. *loquaculus* Dyar and Knab (from Panama, 1909) (♀ lectotype designated by Stone and Knight 1957) all correspond to *Cx. corniger* rather than *Cx. lactator,* based on characters discussed in this paper.

The descriptions for the other two synonyms of *Cx. corniger* indicate their equivalence to that species. The description of *Cx. subfuscus* Theobald (from Jamaica, 1907) includes an illustration of male genitalia showing a strongly developed seta *c* on the subapical lobe, a character of *Cx. corniger.* The male genitalia and other adult characters of *Culex rigidus* Senevet and Abonnenc (from French Guiana, 1939) also correspond to those of *Cx. corniger,* as ac-

Table 2. Number of branches of fourth-instar larval setae of *Culex* (*Culex*) *corniger*. Based on counts made on 11 specimens from 10 collections made in Mexico, Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica.

| Seta No. | Head | Thorax | | | Abdominal Segments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | P | M | T | I | II | III | IV | V | VI | VII | VIII | X |
| 0 | — | 4–8 (4)[a] | — | — | — | 1 | 1 | 1 | 1 | 1 | 1 | 1 | — |
| 1 | 1 | 1 | 1 | 1 | 2–5 (3) | 1 | 1 | 1 | 1 | 1 | 2, 3 (2) | 3–5 (3) | 1 |
| 2 | — | 1 | 2, 3 (2) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 3, 4 (3) | 1 | 1–3 (2) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7–10 (8) | 1 |
| 4 | 2, 3 (2) | 2–4 (4) | 1 | 2–4 (3) | 4–6 (5) | 3–5 (3) | 2–4 (3) | 2 | 2, 3 (2) | 1 | 1 | 1 | 6, 7 (7) |
| 5 | 2–4 (3) | 1 | 1 | 1 | 4, 5 (4) | 1, 2 (1) | 1, 2 (1) | 1 | 1 | 1 | 1–3 (2) | 2–4 (3) | — |
| 6 | 2–3 (2) | 1 | 1 | 1, 2 (1) | 2 | 2 | 2 | 2 | 2 | 2 | 5–9 (6) | — | — |
| 7 | 4–6 (4) | 2, 3 (3) | 1 | 7–10 (8) | 2–4 (3) | 2, 3 (3) | 3–6 (5) | 4–6 (4) | 3–5 (3) | 1 | 1 | 1a-S, | 3, 4 (4) |
| 8 | 1 | 3, 4 (3) | 5–8 (6) | 4, 5 (5) | — | 1, 2 (1) | 1, 2 (2) | 1–3 (2) | 2 | 1–4 (3) | 2, 3 (2) | 1b-S, | 3, 4 (4) |
| 9 | 3, 4 (4) | 1 | 6–9 (7) | 5–8 (6) | 2, 3 (2) | 1 | 1 | 1 | 1 | 1 | 1–3 (2) | 1c-S, | 3–5 (3) |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1d-S, | 2–4 (4) |
| 11 | 3–5 (3) | 3–5 (3) | 2–4 (4) | 2–6 (3) | 4–8 (4) | 1, 2 (2) | 2, 3 (2) | 2 | 2 | 2, 3 (2) | 1, 2 (1) | 1e-S, | 3, 4 (4) |
| 12 | 2–4 (2) | 1 | 1 | 1 | 1, 2 (1) | 2 | 2, 3 (2) | 2, 3 (2) | 1 | 1 | 1 | 1f-S, | 4 |
| 13 | 2 | — | 4–6 (5) | 3–7 (4) | 2 | 4–6 (5) | 2 | 2 | 2 | 4–7 (5) | 1 | — | — |
| 14 | 1, 2 (1) | 1 | 4–6 (5) | — | — | — | 1 | 1 | 1 | 1 | 1 | 1, 2 (1) | — |
| 15 | 2–4 (3) | — | — | — | — | — | — | — | — | — | — | — | — |

[a] Range (mode).

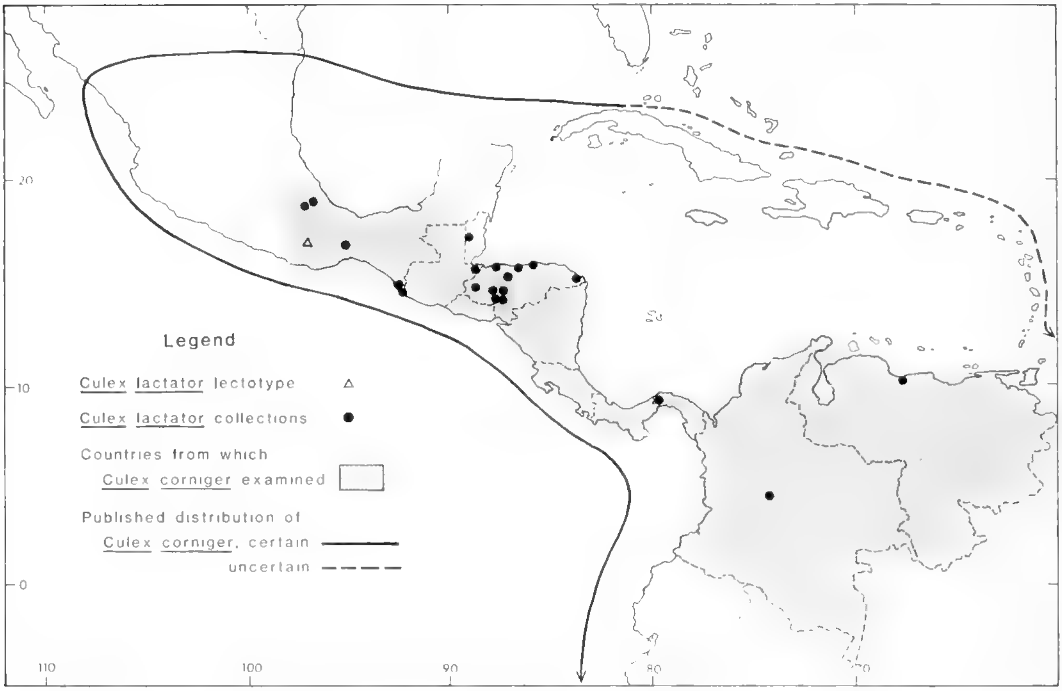


Fig. 17. Geographical distribution of *Cx. lactator* and *Cx. corniger* in northern Latin America.

knowledged by the authors when they later synonymized their species (Senevet and Abonnenc 1958).

We examined specimens of *Cx. corniger* from its type locality, Pará, Brazil. Adults and male genitalia were similar to specimens from Central America. In the original description, Theobald (1903) mentioned characteristics of Central American *Cx. corniger,* including strong mesonotal pattern, incomplete abdominal tergal banding on some segments, and distinct hind tarsal banding.

Distribution (Fig. 17).—According to publications, the distribution of *Cx. corniger* extends from Mexico to Uruguay, including the Caribbean basin. Because our paper is limited geographically to Central America, we can only state with certainty that *Cx. corniger* (as defined here) is present in locations from which we have examined specimens. The distribution of the species in South America may include other species in an unresolved complex (Belkin et al. 1970).

Collection records of specimens examined for this study indicated that the focal distribution of larval *Cx. corniger* includes treeholes, bamboo, and other container habitats. Occasionally, the larvae were found in ground pools. A number of authors have reported these habitats as typical of *Cx. corniger,* including Clark-Gil and Darsie (1983), Belkin et al. (1970), Forattini (1965), and Galindo et al. (1951).

Material examined.—99 ♀ 75 ♂ 64 ♂G 38P 36L from 55 collections. Mexico: Veracruz: Córdoba, 900 m, 14–17 Jul 1964, E. Fisher and D. Verity coll. no. MEX 34 and 41, large treehole, 16 ♀ 8 ♂ 3 ♂G 2P 2L; 800 m, 28 Jul 1965, D. Schroeder coll. no. MEX 237, stream margin with rocks, 4 ♀ 2P 2L; 1000 m, 12 Jul 1965, C. L. Hogue coll. no MEX 380, *Heliconia* flower bracts, 4 ♂ 2 ♂G; 6 Jul 1970, D. and K. Schroeder coll. no. MEX 524, treehole, 3 ♀ 4 ♂ 2 ♂G 2P 2L. Oaxaca: Santa Lucrecia, 19 June 1905, F. Knab coll. no. 262, old tank, 6 ♀ 1 ♂ 1 ♂G; Rincón Antonio, 23 June 1905, F. Knab coll. no. 272, trench, 4 ♀ 2 ♂ 1 ♂G; Tehuan-

Fig. 18. Lateral view of thorax of ♀ *Cx. lactator* (Honduran specimen HONC 241-100, WRBU Acc. 1179).

tepec, 2 July 1905, F. Knab coll. no. 294, tank, 5 ♀ 1 ♂; Alomoloya, 21 Jul 1905, F. Knab coll. no. 312, stream margin rock pool, 1 ♀ 2 ♂ 1 ♂G. Campeche: Campeche, 5 m, 21 Jul 1970, D. and K. Schroeder coll. no. MEX 591, rockhole, 1 ♀ 2 ♂ 2 ♂G 2P 1L; 5 Aug 1970, D. Schroeder coll. no. 602, large rockhole, 2 ♀ 1 ♂ 1 ♂G 2P 2L. Chiapas: Santo Domingo, 815 m, 22 Aug 1987, Strickman, Roberts and Wilkerson coll. no. MX 94, WRBU Acc. 1250, can in cemetery, 12 ♀ 4 ♂ 1 ♂G 2P 2L. Guatemala: Chiquimula: 420 m, 17 Dec 1915, R. Morales, in house, 1 ♀. Guatemala: Guatemala City, 1500 m, 5 Jul 1964, T. J. and J. Zavortink coll. no. GUA 17, hole in cement, 1 ♂G. Retalhuleu: Champerico, <5 m, 2 Jul 1964, V. P. Cowsill coll. no. GUA 21, ground pool, 1 ♂G; San Sebastián, 300 m, 2 Jul 1964, V. P. Cowsill and T. J. Zavortink coll. no. GUAK 29, cut bamboo, 1 ♀ 1 ♂ 2 ♂G. Suchitepéquez: Mazatenango, 380 m, 3 Jul 1964, V. P. Cowsill coll. no. GUA 23, old truck axle, 2 ♀ 1 ♂ ♂G 2P 2L. El Salvador: Sonsonate: Izalco, 430 m, 6 Nov 1971, J. N. Belkin and S. G. Breeland coll. no. SAL 53, treeholes, 1 ♀ 1 ♂ 3 ♂G 2P 2L. Honduras: Atlántida: Río Macora, <5 m, 27 Jul 1985, N. Powers coll. no. HONC 010, WRBU Acc. 1171, stream pool, 9 ♀ 4 ♂ 1 ♂G 2P 2L. Yoro: Río Jalegua, 690 m, 26 Aug 1986, D. Strickman coll. no. HONC 176, WRBU Acc. 1179, crumpled roofing paper, 3 ♀ 5 ♂ 1 ♂G 2P 2L. La Paz: Marcala, 1260 m, 11 Sep 1986, D. Strickman coll. no. 230, WRBU Acc. 1179 military foxhole, 4 ♀ 4 ♂ 1 ♂G 2P 2L. Nicaragua: Chinandega: Corinto, 29 May 1945, 1 ♂ 1 ♂G. Zelaya: Blue Fields, <5 m, 12 Jul 1964, A. Quinonez coll. no. NI 40, ground pool, 1 ♂ 1 ♂G 1P 1L; 13 Jul 1964, coll. no. NI 45, ground pool amid tree roots, 1 ♀ 1 ♂ 2 ♂G 2P 2L; 22 Jul 1964, coll. no. 59, treehole, 1 ♀; 5 m, 25–26 Nov 1971, D. Schroeder coll. no. NIC 101, light trap, 1 ♀. Costa Rica: Alajuela: Alajuela, 880 m, 18 Jul 1971, D. W. Heinemann coll. no. CR 271, 1 ♂; Turrúcares, 650 m, 31 Jul 1971, S. J. Heinemann coll. no. CR 304, rockholes, 1 ♀ 1 ♂ 1 ♂G 1P 2L; 480 m, 31 Jul 1971, S. J. Heinemann and A. Berrios Arias coll. no. CR 308, rockholes, 1 ♀ 1 ♂ 2 ♂G 2P; 3 km E. of San Mateo, 260 m, 1 Nov 1971, D. A. Schroeder coll. no. CR 496, 1 ♀ 1 ♂ 2 ♂G 2P 2L; Ciruelas, 780 m, 4 Nov 1971, D. A. Schroeder coll. no. CR 515, rockhole, 1 ♀ 1 ♂ 2 ♂G 2P 2L. Cartago: Turrialba, 500 m, 23 Aug 1971, D. W. Heinemann coll. no. CR 390, rockholes, 1 ♂. Guanacaste: 10 km NW of Liberia, 60 m, 6 Aug 1964, C. L. Hogue coll. no. CR 187, rockhole, 1 ♀ 1 ♂ 2 ♂G 2P 2L; 23 Jun 1964, coll. no. CR 182, resting on rock, 1 ♀; Alajuelita, 1090 m, 23 Jul 1971, S. J. Heinemann coll. no. CR 284, 1 ♀ 1 ♂ 1 ♂G; coll. no. CR 286, rockhole, 2 ♀; coll. no. CR 285, rockhole, 2 ♀; coll. no. CR 288, rockhole, 1 ♂G; Puerto Humo, 10 m, 20 Jun 1975, J. Hayes coll. no. CR 601, tire, 1 ♀ 1 ♂ 1 ♂G. Limón: Westfalia, <5 m, 4 Dec 1962, C. L. Hogue and W. A. Powder coll. no. 72, 1 ♀; 8 km E. of Zent, 20 m, 17 Dec 1971, D. A. Schroeder coll. no. CR 564, treehole, 1 ♀; Limón, 10 m, 16 Jul 1975, J. Hayes coll. no. CR 610, biting human, 1 ♀. Puntarenas: Cerrillos, 1938, H. W. Kumm coll. no. CRK 599, 1 ♂ 1 ♂G; 7 km E. of Palmar Norte, 40 m, C. L. Hogue coll. no. CR 163, treehole, 1 ♀ 1 ♂ 4 ♂G 2P 2L; 6 km S. of San Vito, 30 Apr 1967, D. F. Veirs, 1

♀; Las Loras nr. Puntarenas, 9 Sep 1905, F. Knab coll. no. 334, ground pool, 1 ♂, 1 ♂G. San José: San José, 21 Sep 1905, F. Knab coll. no. 343, barrel, 1 ♀; San Isidro del General, 750 m, 23 Jun 1964, C. L. Hogue coll. no. CR 180, concrete pond, 1 ♀ 1 ♂ 1 ♂G 2P 2L; Santa Ana, 860 m, 25 Jul 1971, A. Berrios Arias and S. J. Heinemann coll. no. CR 293, broken bamboo, 1 ♀ 1 ♂ 1 ♂G; Santa Ana, 1938, H. W. Kumm coll. no. CRK 283, 1 ♀ 1 ♂ 1 ♂G; 4 km E. of San Isidro de Coronado, 1520 m, 30 Jul 1971, D. W. and S. J. Heinemann coll. no. CR 300, ditch, 1 ♀. No location within country: 3 ♂G. Panama: Corozal, USNM Type No. 12050, ♀, lectotype of *Culex lactator* var. *loquaculus*. Jamaica: Kingston, M. Grabham, ♂, lectotype of *Culex hassardii*. Trinidad: F. W. Urich, USNM Type No. 10021, ♀, lectotype of *Culex basilicus*. Brazil: Pará, Apr 1930, N. C. Davis, 11 ♂ 11 ♂G. Representative specimens from Panama, Colombia, and Venezuela were examined.

### ***Culex* (*Culex*) *lactator***
### **Dyar and Knab**

*Culex lactator* Dyar and Knab, 1906a: 209, Fig. 23 (Rincón Antonio, Oaxaca, Mexico, larva). RESURRECTED FROM SYNONYMY.

*Culex lactator* var. *lactator* Dyar and Knab, 1909: 254 (adult).

*Culex corniger* var. *lactator* Howard, Dyar, and Knab, 1915: 240 (adult).

*Culex corniger* Theobald, Dyar, 1922: 23 (*lactator* in synonymy).

The following description lists characters of *Cx. lactator* which are different from those of *Cx. corniger*.

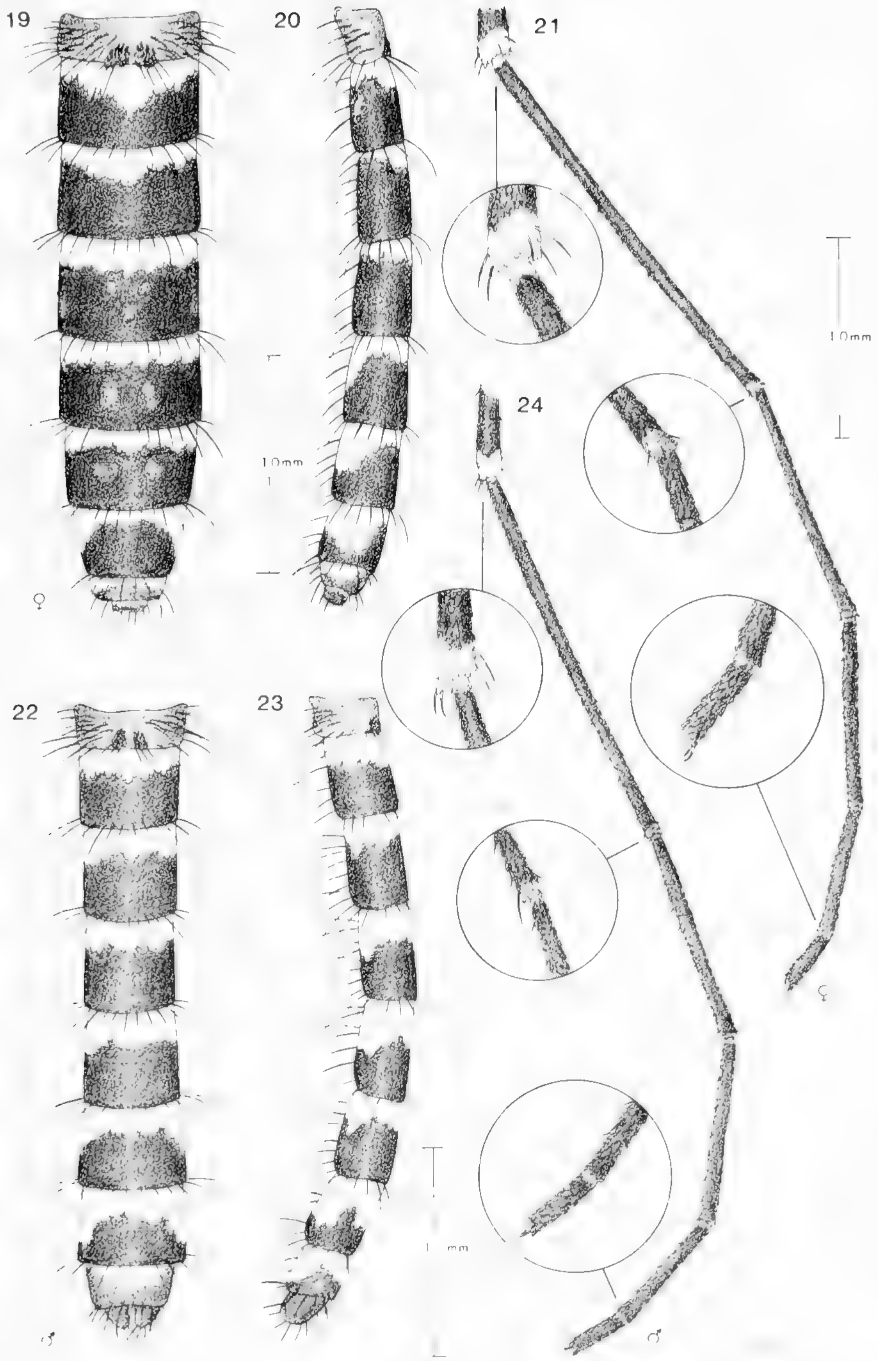
Female (Figs. 1, 18, 19–21).—*Head:* Decumbent scales of vertex yellowish, dingy white on ocular line. Broad dingy white scales on postgena. *Thorax:* Mesonotum as in Fig. 1; background scales dark brown ($B_{90}Y_{70}M_{99}$) adjacent to light areas, on scutal fossa, and along dorsocentral and acrostichal lines; other background scales lighter brown with gold reflection; lateral scutal fossal light scales sometimes four rows wide in anterior portion; or less numerous, causing break in pattern; posterior dorsocentral light scale sometimes few, absent, or isolated so they form spots or sometimes pattern formed by light scales inconspicuous. Scutellar scales narrowest on posterior median part of midlobe. Pleura as in Fig. 18. Antepronotum with narrow yellowish scales on ventral portion. Postpronotum with narrow golden scales along dorsal margin. Proepisternum with sparse, broad, yellowish scales. *Legs:* Foretarsus entirely dark. Midtarsus dark with narrow, poorly defined bands of slightly lighter scales at base and apex of tarsomeres 1, 2, base of tarsomere MT-3. Hindtibia with light apical band 3–4 scales wide. Hindtarsus as in Fig. 21. *Abdomen:* Terga as in Figs. 19, 20; basal light bands reach lateral spots on terga I–VII. Sternum V covered with slightly yellowish scales; VI and VII with posterolateral or complete posterior bands of dark scales.

Male (Figs. 22–24).—Differences from female similar to those listed for *Cx. corniger*.

Male genitalia (Figs. 25–29).—*Ninth tergum* (Fig. 29): Tergum deeply cleft between lobes; setae in three or four irregular rows. *Proctiger* (Fig. 28): Basal lateral arm usually narrows slightly, then widens to rounded, excavated tip; cercal setae 2–6 (mode = 3). *Gonocoxopodite* (Fig. 25): Seta *c* only occasionally present (one side of one specimen, both sides of another) as rod much finer than seta *c* in *Cx. corniger*; gonostylus with slightly lumpy outline.

Pupa (Figs. 30, 31; Table 3).—*Abdomen:* Posterior of sternum II with stout spicules. *Chaetotaxy:* As in Table 3; Figs. 30, 31.

Larva (Fig. 32; Tables 4, 5).—*Head:* Antenna gradually darker from seta 1 to tip; mean antennal tuft ratio (distance from antennal base to seta 1-A divided by antenna length) 0.49 (SD = 0.04, min = 0.40, max = 0.59, n = 104). *Thorax:* Spiculation coarser on dorsal and sometimes ventral surfaces of meso- and metathorax; spicu-



Figs. 19–24. Adult *Cx. lactator* from Honduras (WRBU Acc. 1179; ♀ HONC 241-100; ♂ HONC 241-21). Scale bars do not apply to magnified insets. 19, Female abdomen, dorsal view. 20, Female abdomen, lateral view. 21, Female hindtarsus and apex of hindtibia, anterior view. 22, Male abdomen, dorsal view. 23, Male abdomen, lateral view. 24, Male hindtarsus and apex of hindtibia, anterior view.

Figs. 25–31. Male genitalia and pupal exuviae of *Cx. lactator.* Drawn from Mexican specimens MX 19-1 and 19-100, WRBU Acc. 1250 (genitalia) and Honduran specimens HONC 241-19 and 241-20, WRBU Acc. 1179 (pupa). 25, Gonocoxopodite, mesal view. 26, Lateral plate, lateral and mesal views. 27, Phallosome, dorsal view. 28, Proctiger, dorsal view. 29, Ninth tergal lobes, dorsal view. 30, Pupal cephalothorax (CT), anterior lateral quadrant. 31, Metathoracic wings and abdomen (P = paddle; each magnified inset is 0.05 mm across).

Table 3. Number of branches of pupal setae of *Culex* (*Culex*) *lactator*. Based on counts made on 14 specimens from 11 collections in Mexico and Honduras.

| Seta No. | CT | Abdominal Segments | | | | | | | | | Paddle |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX | P |
| 0 | – | – | 1 | 1 | 1 | 1 | 1 | 1 | 1, 2 (1)[a] | – | – |
| 1 | 1, 2 (1) | 9–14 (11) | 6–14 (10) | 2–4 (3) | 2, 3 (2) | 1–3 (2) | 1, 2 (1) | 1, 2 (1) | – | 1 | 1–3 (1) |
| 2 | 2 | 1, 2 (2) | 1, 2 (1) | 1 | 1 | 1 | 1 | 1 | – | – | 1, 2 (1) |
| 3 | 1 | 1, 2 (2) | 2 | 2 | 3–5 (5) | 1, 2 (2) | 1, 2 (2) | 1 | – | – | – |
| 4 | 2–4 (2) | 3–5 (5) | 2–5 (3) | 3–6 (4) | 2–5 (3) | 2–4 (3) | 1–3 (2) | 1, 2 (1) | 1, 2 (1) | – | – |
| 5 | 2–5 (3) | 3–8 (3) | 1, 2 (1) | 1–3 (2) | 1 | 1 | 1 | 1 | – | – | – |
| 6 | 1–3 (2) | 1 | 1, 2 (1) | 1 | 1 | 1 | 1 | 2–7 (4) | – | – | – |
| 7 | 2 | 2 | 1–3 (2) | 3–5 (4) | 2–5 (3) | 2–5 (4) | 1 | 1 | – | – | – |
| 8 | 1, 2 (1) | – | – | 2–5 (3) | 2–4 (3) | 2–4 (3) | 2–4 (3) | 1–3 (2) | – | – | – |
| 9 | 1, 2 (2) | 1, 2 (2) | 1 | 1 | 1 | 1 | 1 | 2–4 (2) | 4–7 (5) | – | – |
| 10 | 4–8 (5) | – | – | 1, 2 (1) | 1, 2 (2) | 1 | 1 | 1 | – | – | – |
| 11 | 2, 3 (2) | – | – | 1 | 1 | 1 | 1 | 1, 2 (1) | – | – | – |
| 12 | 1, 3 (2) | – | – | – | – | – | – | – | – | – | – |
| 13 | – | – | – | – | – | – | – | – | – | – | – |
| 14 | – | – | – | 1 | 1 | 1 | 1 | 1 | 1, 2 (1) | – | – |

[a] Range (mode).

lation clearly visible on dorsal side of the mesothorax at 40×, elsewhere at 100×. *Siphon:* Mean spiracular apodeme ratio (length of spiracular apodeme divided by dorsal length of siphon) 0.45 (SD = 0.035, min = 0.36, max = 0.56, n = 107); modal number of siphon tufts 6 (min = 5, max = 7, n = 107); other quantitative larval measurements in Table 5. *Chaetotaxy:* As in Table 4; Fig. 32.

Lectotype (Figs. 33–42).—Includes adult male and associated genitalia, larval and pupal exuviae on slides. *Adult male:* Glued to point with right wing detached and glued separately; right hindleg absent; dark scales faded compared to recently collected specimens (brown $B_{60}Y_{99}M_{80}$ on proboscis, $B_{50}Y_{90}M_{70}$ on hindfemur, $B_{40}Y_{90}M_{80}$ on abdominal terga); some scales of pleuron rubbed off. *Male genitalia:* Includes VI–VIII, cleared but undissected, gonostyli and subapical lobes arranged for easier viewing. Ninth tergum and proctiger have been pushed downward (ventrally) and apically, distorting their relationship with lateral plates. In Fig. 34, ventral arms of lateral plates appear mesad of lateral lobes. *Larva:* Divided at abdominal segment VII, thorax and abdomen twisted. *Pupa:* Good condition.

Diagnosis.—*Culex lactator* can be distinguished from other members of the subgenus in Central America north of Panama by the following features. *Adult:* Proboscis with light band (though not always completely surrounding proboscis); mesonotal pattern characteristic (Fig. 1); bands of tarsi narrow, poorly defined and not extending beyond base of tarsus 3. Basal light bands on abdominal terga II-VII connected laterally to lateral light spots. *Male genitalia:* Ninth tergum deeply cleft with numerous setae on lobes; lobes connected by broad strap of cuticle; lateral plate of characteristic form, dorsal process poorly developed; lateral lobe well developed; subapical lobe with setae *a, b, d-f, g* (foliform), and *h* present; gonostylus narrowed beyond basal 0.3. *Larva:* Antenna not markedly tapered in apical portion; tuft (seta 1-A) with 3 or fewer branches; linear combination of characters (see Discussion) including (in order of importance) saddle index, branches of seta 4-C, siphon index, branches of seta 7-C, ratio of distance to

Table 4. Number of branches for fourth-instar larval setae of *Culex* (*Culex*) *lactator.* Based on counts made on 14 specimens from 11 collections made in Mexico and Honduras.

| Seta No. | Head | Thorax | | | Abdominal Segments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | P | M | T | I | II | III | IV | V | VI | VII | VIII | X |
| 0 | — | 4–8 (5)[a] | — | — | — | 1 | 1 | 1 | 1 | 1 | 1 | 1 | — |
| 1 | 1 | 1 | 1 | 1, 2 (1) | 1–4 (2) | 1 | 1 | 1 | 1 | 1 | 1–4 (3) | 2–6 (3) | 1 |
| 2 | — | 1 | 2–5 (2) | 1, 2 (1) | 1 | 1 | 1 | 1 | 1, 2 (1) | 1 | 1 | 1 | 1 |
| 3 | 1 | 3, 4 (3) | 1 | 2–4 (2) | 1 | 1 | 1 | 1–3 (1) | 1 | 1 | 1 | 7–12 (8) | 1 |
| 4 | 2–4 (3) | 3–5 (4) | 1 | 2–4 (2) | 3–7 (4) | 2–6 (4) | 2–4 (2) | 1, 2 (2) | 2–4 (3) | 1, 2 (1) | 1 | 1 | 6–8 (7) |
| 5 | 2–4 (3) | 1 | 1 | 1 | 2–6 (4) | 1–3 (1) | 1 | 1, 2 (1) | 1 | 1 | 1–4 (2) | 2–4 (3) | — |
| 6 | 2–4 (3) | 1 | 1, 2 (1) | 1 | 2, 3 (2) | 2, 3 (2) | 2, 3 (2) | 2, 3 (2) | 2 | 2 | 4–11 (5) | — | — |
| 7 | 4–9 (6) | 2–4 (3) | 1–3 (1) | 8–12 (9) | 3, 4 (3) | 2–4 (3) | 3–6 (4) | 4–6 (4) | 3–5 (3) | 1 | 1, 2 (1) | 1a-S. | 3, 4 (4) |
| 8 | 1 | 3, 4 (3) | 4–8 (7) | 4–9 (6) | — | 1 | 1, 2 (1) | 1, 2 (1) | 1, 2 (2) | 1–5 (3) | 1–5 (2) | 1b-S. | 3, 4 (3) |
| 9 | 3–5 (4) | 1 | 6–11 (7) | 6–11 (8) | 2, 3 (2) | 1 | 1 | 1 | 1 | 1 | 1 | 1c-S. | 2–4 (3) |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1, 2 (1) | 1 | 1 | 1 | 1d-S. | 2–5 (3) |
| 11 | 2–4 (3) | 2–5 (4) | 3–5 (4) | 1–6 (4) | 4–9 (6) | 1–3 (2) | 1–3 (2) | 1–3 (2) | 1–3 (2) | 2, 3 (2) | 1–3 (1) | 1e-S. | 2–4 (2) |
| 12 | 2, 3 (3) | 1 | 1 | 1 | 1, 2 (1) | 1–4 (2) | 1–3 (2) | 1–3 (2) | 1, 2 (1) | 1, 2 (1) | 1 | 1f-S. | 2–4 (2) |
| 13 | 1–3 (2) | — | 5–10 (6) | 2–4 (3) | 2, 3 (2) | 4–9 (5) | 2, 3 (2) | 2 | 2, 3 (2) | 5–9 (6) | 1 | — | — |
| 14 | 1, 2 (1) | 1 | 4–9 (7) | — | — | — | 1 | 1 | 1 | 1 | 1 | 1, 2 (1) | — |
| 15 | 2–4 (3) | — | — | — | — | — | — | — | — | — | — | — | — |

[a] Range (mode).

Table 5. Comparisons of quantifiable larval characters used to distinguish *Culex corniger* from *Culex lactator*. The characters are listed in order of importance.

| Larval Character | Mean ± SD (n) and Range | |
|---|---|---|
| | *Cx. lactator* | *Cx. corniger* |
| Saddle index[a] | 2.13 ± 0.14 (106)<br>1.58–2.59 | 1.87 ± 0.11 (33)<br>1.61–2.09 |
| No. 4-C branches[b] | 3 (97)<br>2–4 | 2 (31)<br>2–3 |
| Siphon index[c] | 1.71 ± 0.21 (108)<br>1.18–2.48 | 1.82 ± 0.28 (33)<br>1.23–2.41 |
| No. 7-C branches[b] | 6 (104)<br>4–9 | 4 and 5 (33)<br>4–7 |
| 1a-S ratio[d] | 0.21 ± 0.05 (108)<br>0.14–0.60 | 0.27 ± 0.05 (33)<br>0.17–0.36 |
| No. pecten spines[b] | 9 (108)<br>6–15 | 10 (33)<br>8–13 |
| Pecten row index[e] | 0.58 ± 0.05 (107)<br>0.37–0.73 | 0.61 ± 0.06 (33)<br>0.48–0.73 |

[a] Dorsal length of siphon divided by dorsal length of saddle.

[b] Mode (n) and range.

[c] Dorsal length of siphon divided by width of siphon at base.

[d] Distance from base of siphon to first siphon tuft divided by dorsal length of siphon.

[e] Distance from dorsal base of siphon to last pecten spine divided by dorsal length of siphon.

seta 1a-S (from base of siphon) to siphon length, number of pecten teeth, and pecten row length index.

Distribution (Fig. 17).—We found specimens of *Cx. lactator* in collections from central Mexico to central Colombia. The lack of specimens from Nicaragua and Costa Rica was unexpected, but more thorough collecting in habitats suited to *Cx. lactator* would probably find the species in those countries. The species is apparently absent from the Caribbean. Its distribution in South America is uncertain because the *corniger* group may include undescribed species which resemble *Cx. lactator*. For example, two male genitalia from Ecuador resemble the genitalia of *Cx. lactator*, but because they are not associated with adults, identification is uncertain.

Collections of larval *Cx. lactator* have been made from sea level to 1500 m. The species has usually been found in sunlit water in contact with soil, such as ground pools, stream margins, and lake margins. Most of the sites had been fouled either by natural vegetation or domestic activity. Only one collection was taken from a container, a liter can in a cemetery, but the can rested on the ground and contained rotting vegetation. Although the focal distribution of *Cx. lactator* is distinct from that of *Cx. corniger*, these species occasionally share the same larval habitat (Honduras: HONC 316, WRBU Acc. 1221; Mexico: MEX 237).

Material examined.—Total 150 ♀ 145 ♂ 39 ♂G 163P 110L in 30 collections. Mexico: Oaxaca: Rincón Antonio, lectotype, 23 Jun 1905, F. Knab coll. no. 270i, "Ditch containing a small quantity of very thick and foul water among bones and other rubbish, and swarming with mosquito larvae and pupae.", 1 ♂ 1 ♂G 1P 1L, also in series 5 ♀ 4 ♂ 1 ♂G. Veracruz: Córdoba, 10 Jun 1905, F. Knab coll. no. 258, 2 ♀ 1 ♂ 1 ♂G; 600 m, 26 Jul 1965, D. Schroeder and R. X. Schick coll. no. MEX 235, margin artificial lake, 3 ♀ 1 ♂ 2 ♂G 4P 9L; 1100 m, 28 Jul 1965, D. Schroeder coll. no. MEX 237, stream margin, 1 ♀ 1P 1L; Orizaba, 1300 m, 11 Aug 1965, D. Schroeder and R. X. Schick coll.

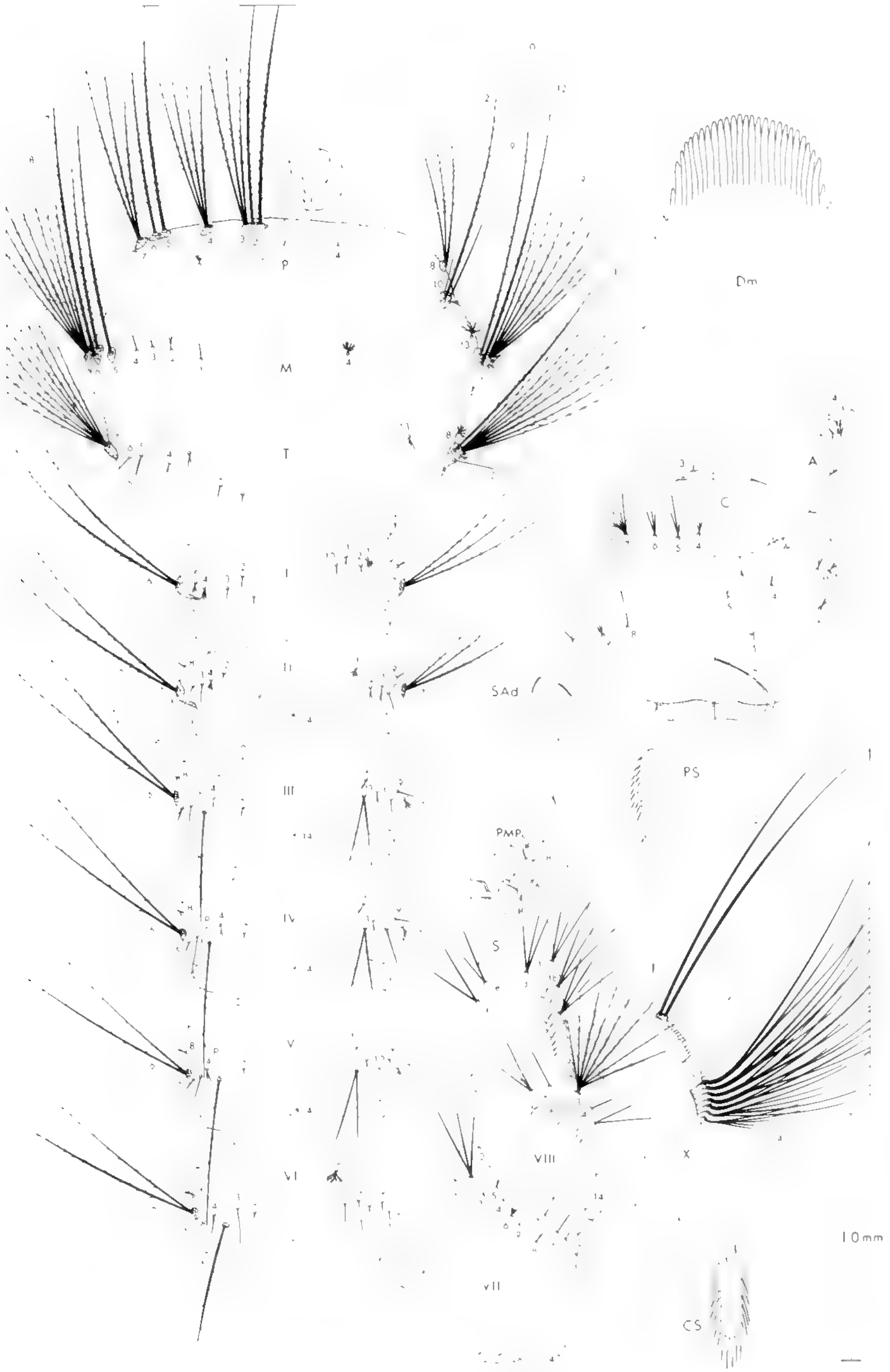
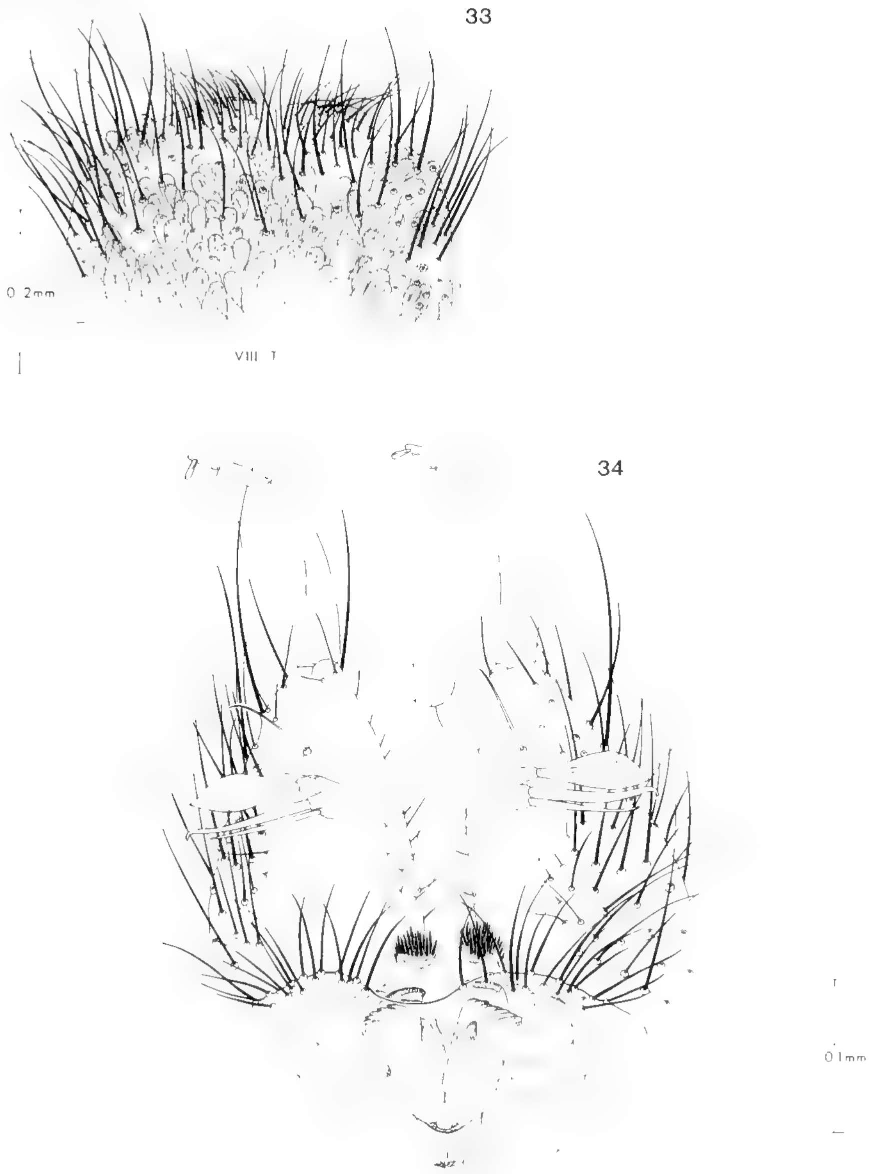
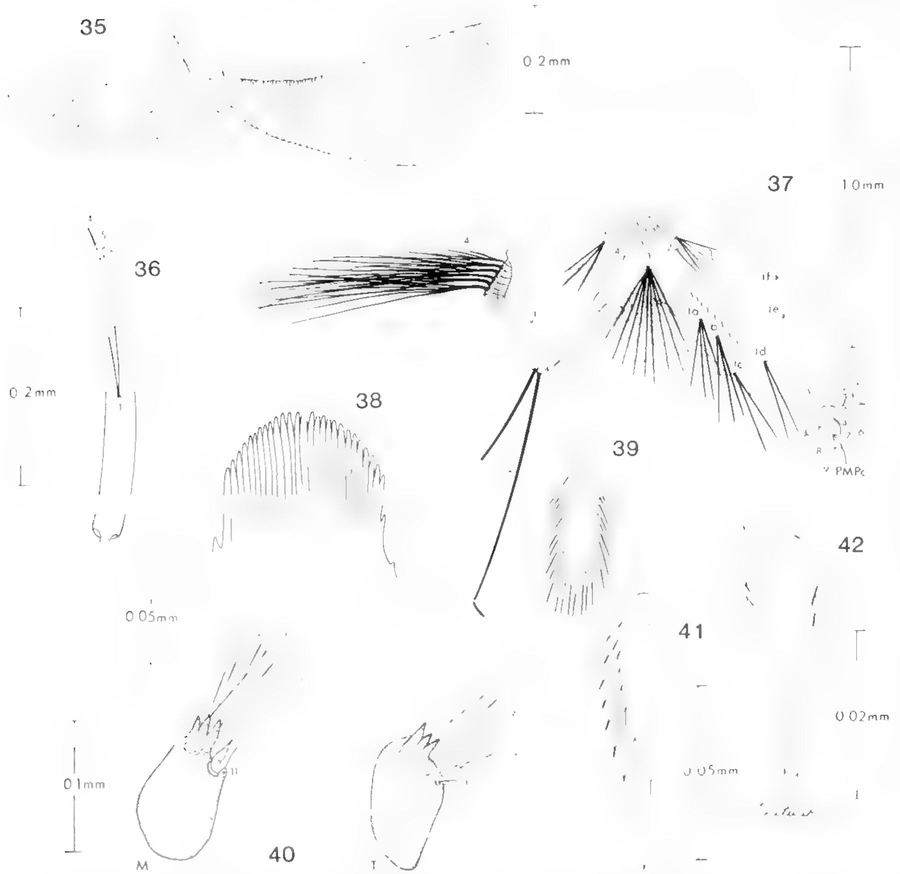


Fig. 32. Larva of *Cx. lactator* Honduran specimens HONC 241-19 and 241-20, WRBU Acc. 1179. Scale does not apply to enlargements of dorsomentum, spiracular apodeme, pecten spine, or comb scale; each magnified inset of spiculation is 0.07 mm across. (A = antenna; C = head; CS = comb scale; Dm = dorsomentum; M = mesothorax; P = prothorax; PMPc = posterior median process; PS = pecten spine; S = siphon; SAd = spiracular apodeme; T = metathorax.)



Figs. 33, 34 Male terminalia of *Cx. lactator* lectotype. 33, Eighth abdominal tergum. 34, Genitalia as they appear on slide mount.

no. MEX 291, concrete pit, 1 ♂ 1 ♂G 1P. Oaxaca: Matías Romero, 200 m, 1 Sep 1965, D. Schroeder coll. no. MEX 335, 2 ♀ 9 ♂ 3 ♂G 12P 16L. Chiapas: El Gancho, sea level, 15 Aug 1987, Strickman, Roberts, and Wilkerson coll. no. MX 19, post hole, 8 ♀ 2 ♂ 4 ♂G 14P 6L; Tapachula, 100 m, 7 Sep 1987, Strickman, Roberts, and Wilkerson coll. no. MX 176, can on ground, 1 ♀ 1 ♂ 1 ♂G. Belize: Cayo: Central Farm, 70 m, 9-10



Figs. 35–42. Details of pupal and larval exuviae of *Cx. lactator* lectotype. 35, Pupal trumpet. 36, Larval antenna. 37, Terminal larval segments. 38, Dorsomentum. 39, Comb scale. 40, Setal support plates for setae 9-12-M and 9-12-T. 41, Pecten spine. 42, Spiracular apodeme with base of posterior median process.

May 1967, D. S. Bertram coll. no. BH A128, light trap, 1 ♂ 1 ♂G. Guatemala: Izabal: Cayuga, 1 ♂G. Honduras: Copán: nr. San Jose de Copán, 12 Mar 1987, D. B. Francy, WRBU Acc. 1254, light trap, 2 ♀ 6 ♂G. Cortés: Puerto Cortés, <5 m, 10 Aug 1967, A. J. Adames coll. no. HON 63, ground pool, 1 ♀ 4P 1L. Atlántida: La Ceiba, 10 m, 18 Jul 1986, D. Strickman coll. no. HONC 92, WRBU Acc. 1179, roadside ditch, 1 ♀ 1P 1L. Yoro: Camp Big Bear, 800 m, 29 Apr 1986, R. Johnson coll. no. HONC 316, WRBU Acc. 1221, shower runoff, 25 ♀ 20 ♂ 1 ♂G 44P 15L. Comayagua: Comayagua, 590 m, 20 Mar 1984, A. R. Gillogly coll. no. HONK 16, WRBU Acc. 1076, stream margin pool, 2 ♀ 1 ♂ 1 ♂G 2P 2L; Palmerola Air Base, 630 m, 23 Nov 1983, J. J. Arnott coll. no. HO 11-1-23, WRBU Acc. 1067, road rut, 23 ♀ 13 ♂ 1P 1L; 6 Jul 1985, N. Powers coll. no. 002, WRBU Acc. 1171, stream margin, 1P 1L; 6 Jul 1985, coll. no. HONC 003, ditch, 2 ♀ 1 ♂ 5P 5L; 17 Jul 1985, coll. no. 006, ditch, 20 ♀ 22 ♂ 3 ♂G 42P 43L; 31 Jul 1986, D. Strickman coll. no. HONC 117, WRBU Acc. 1179, shower runoff, 1 ♀ 2 ♂ 1 ♂G; 31 Jul 1986, coll. no. HONC 118, ditch, 2 ♀ 1 ♂ 1 ♂G; 17 Sep 1986, coll. no. HONC 241, kitchen waste water, 6 ♀ 6 ♂ 1 ♂G 12P 6L; Siguatepeque, 1100 m, 21 Jul 1986, D. Strickman coll. no. HONC 94, WRBU Acc. 1179, 2 ♀ 1 ♂ 1 ♂G 3P 3L. La Paz: Cerro Sosomico, 1200 m, 27 Jul 1986, D. Strickman coll. no. HONC

107, WRBU Acc. 1179, ground pool, 1 ♀. Colón: Puerto Castilla, <5 m, 10 Aug 1964, A. Quinonez coll. no. HO 21, ditch, 4 ♀ 6 ♂ 2 ♂G 8P. Gracias a Dios: Puerto Lempira, <5 m, 17 Jun 1986, D. Strickman coll. no. HONC 27, WRBU Acc. 1179, ground pool, 1 ♀ 1P. Panama: Canal Zone: Summit, 16 Aug 1923, Dyar and Shannon, 5 ♀ 12 ♂ 1 ♂G; 4 May 1935, coll. no. PAX 45, 6 ♀ 15 ♂ 1 ♂G. Colombia: Cundinamarca: Fusagasuga, 1500 m, 3 Mar 1965, A. M. Alarcon and E. Osorno-Mesa coll. no. COB 16, ground pool, 3 ♀ 3 ♂ 1 ♂G. Venezuela: Aragua: Turmero, 500 m, 5 Sep 1966, E. R. Vasquez coll. no. VZ 32, ground pool, 21 ♀ 21 ♂ 4 ♂G 8P 1L.

## DISCUSSION

*Culex lactator* and *Cx. corniger* are similar species which are most easily separated as adults. *Culex corniger* is generally darker with greater contrast between light and dark areas. The dorsum of the abdomen of female *Cx. corniger* has light bands at the base of each segment that became progressively less extensive posteriorly until, at segments V and VI, the bands do not reach the lateral spots. On some specimens only a few light scales are present anywhere on the dorsum of the abdomen. In contrast, females of *Cx. lactator* have broader basal abdominal bands which reach the lateral spots on all segments. There is a marked difference between the two species in the banding on the hindtarsus. *Culex corniger* has distinct light bands on the proximal tarsomeres and less distinct bands on tarsomeres 4 and 5; whereas, *Cx. lactator* has less distinct light bands on the proximal tarsomeres and bands either absent or reduced to a few scales on tarsomeres 4 and 5.

In the male genitalia, *Cx. corniger* differs from *Cx. lactator* in the consistent presence of a moderately stout third rod (seta *c*) proximal to the leaf (seta *g*), a gonostylus that narrows less markedly in its apical two thirds, and a thinner, less deeply cleft connection between the lobes of the ninth tergum. The lateral plates of the two species are very similar. The rare presence of seta *c* in *Cx. lactator* (in 2 of 39 examined) places some doubt on the diagnostic usefulness of this character; however, in both cases seta *c* was markedly weaker than in *Cx. corniger.*

The larvae of *Cx. corniger* and *Cx. lactator* share the same distinctive form of head and siphon. Seven characters enabled separation of some, but not all, of the specimens examined (Table 5). Although the saddle index could be used to identify many of the specimens, separation of species was improved by using combinations characters (Table 6). Each character was multiplied by a coefficient that weighted it according to its importance in separating the species. The sum of the products yielded the canonical variable (CNV), the value of which determined the species identification. The formula below was arranged so that the characters appear in their order of importance (i.e. the first character is the one which would provide the best separation by itself, the second character would separate the next largest number of specimens, etc.). Use of fewer characters simply requires elimination of products beginning from the right side of the formula.

$$\begin{aligned}\mathrm{CNV} = {} & 5.45(\mathrm{A}) + 0.74(\mathrm{B}) - 2.07(\mathrm{C}) \\ & + 0.36(\mathrm{D}) - 4.42(\mathrm{E}) \\ & - 0.15(\mathrm{F}) - 3.50(\mathrm{G})\end{aligned}$$

where:

A = saddle index (dorsal length of siphon/dorsal length of saddle)
B = branches of seta 4-C
C = siphon index (dorsal length of siphon/width of siphon at base)
D = branches of seta 7-C
E = base of siphon to insertion of seta 1a-S/dorsal length of siphon
F = number of pecten teeth
G = pecten row length index (dorsal base of siphon to apical pecten tooth/dorsal length of siphon).

Determination of specimens not included in the original analysis supported the use of the canonical variable. Both the lectotype

Table 6. Canonical variable (CNV) values separating *Culex lactator* and *Cx. corniger* based on the use of one, two, three, or seven characters. Use of 4–6 characters was no more accurate than use of three characters. Specimens examined were from Central America.

| Species | Statistic | No. of Parameters | | | |
|---|---|---|---|---|---|
| | | 7[a] | 3[b] | 2[c] | 1[d] |
| *Cx. lactator* | CNV cutoff[e] | >6.25 | >9.25 | >12.75 | >11 |
| | Sensitivity[f] | 96% | 93% | 91% | 84% |
| | Mean CNV | 8.11 | 10.28 | 13.79 | 11.61 |
| | CNV range | 5.25–10.25 | 7.84–12.18 | 10.81–15.85 | 8.61–14.12 |
| *Cx. corniger* | CNV cutoff | ≤6.25 | ≤9.25 | ≤12.75 | ≤11 |
| | Sensitivity | 97% | 93% | 90% | 88% |
| | Mean CNV | 4.98 | 8.04 | 11.78 | 10.19 |
| | CNV range | 3.25–7.25 | 6.70–9.47 | 10.74–12.87 | 8.77–11.39 |
| Both | Accuracy[g] | 96% | 93% | 90% | 85% |

[a] CNV = 5.45(saddle index) + 0.74(branches of seta 4-C) - 2.07(siphon index) + 0.36(branches of seta 7-C) − 4.42(base of siphon to insertion of seta 1a-S/dorsal length of siphon) − 0.15(number of pecten teeth) − 3.50(pecten row length index).

[b] CNV = 5.45(saddle index) + 0.74(branches of seta 4-C) − 2.07(siphon index).

[c] CNV = 5.45(saddle index) + 0.74(branches of seta 4-C).

[d] CNV = 5.45(saddle index).

[e] Optimum value of CNV to accurately distinguish the most specimens of each species.

[f] Sensitivity = percentage correctly identified out of total examined of that species.

[g] Accuracy = percentage of both species correctly identified out of total examined.

(CNV = 7.28) and specimen VZ 32-62 from Venezuela (CNV=7.33) were well within the range of CNV values (Table 6) for *Cx. lactator.* Collection MEX 237 from Mexico included adults of both *Cx. corniger* and *Cx. lactator.* Associated larval exuviae yielded canonical variable values that corresponded to identifications of the adults: MEX 237-41, CNV = 5.82; MEX 237-93, CNV = 5.29; MEX 237-95, CNV = 7.20.

At a practical level, use of all seven characters would rarely be necessary. The ninety percent accuracy possible using a CNV calculated from a combination of the saddle index and seta 4-C (two parameters in Table 6) would probably be adequate for most purposes, especially since usually only one of the species would be collected from a single site.

A similar discriminant analysis was performed for pupae of the two species (152 specimens of *Cx. lactator,* 35 of *Cx. corniger*). Although statistically significant ($P < 0.01$) separation was achieved, accuracy was only 83%, even using seven characters. We do not consider this level of accuracy sufficient for useful identification. The stouter spiculation on the posterior of sternum II in *Cx. lactator* versus the finer spiculation in *Cx. corniger* separates most specimens, but it is difficult to evaluate specimens without comparative material.

Of the other species in Central America that have adults with banded hindtarsi, only *Cx. coronator* Dyar and Knab and *Cx. restuans* Theobald might be confused with *Cx. lactator* or *Cx. corniger. Culex coronator* may be identified by a weakly developed mesonotal pattern and strongly developed banding on the hindtarsus, particularly on tarsomere 5. *Culex restuans* sometimes closely resembles adults of *Cx. lactator,* but the mesonotal pattern is weaker anteriorly and the hindtarsal banding is wider and extends to the base of tarsomere 5 (Strickman and Darsie 1988).

## CONCLUSION

The wide distribution and morphological variability of *Cx. corniger* led to the naming of five species and one variety which were later synonymized. We have found that one synonym, *Cx. lactator,* represents a species that is distinguishable in all stages but the pupa from sympatric populations of *Cx. corniger.* For this reason, we have elevated *Cx. lactator* to species status.

The previous descriptive literature on *Cx. lactator* was inadequate to identify the species. Dyar and Knab's (1906a) original description of this species was part of a revision of *Culex* larvae which did not include *Cx. corniger.* Of the seven collections cited by Dyar and Knab (1906a), two (from Córdoba and Rincón Antonio) were *Cx. lactator* and five (from Santa Lucrecia, Tehuantepec, Almoloya, Puntarenas, and San Jose) were *Cx. corniger.* The various adult forms were later organized into varieties, culminating in the short key by Howard et al. (1915). Dyar and Knab evidently never associated *Cx. lactator* with its male genitalia, because they illustrated descriptions of *Cx. corniger* with genitalia of *Cx. lactator* in two publications (Howard et al. 1912, Dyar 1928). Fortunately, certain identification is possible since the male prepared by Knab and selected by Stone and Knight (1957) as the lectotype of *Cx. lactator* has associated larval and pupal exuviae as well as genitalia.

Subsequent treatments of *Cx. corniger* in Central America gave little indication of a separate form corresponding to *Cx. lactator.* Lane (1953) mentioned that seta *c* is sometimes absent on the subapical lobe of the male genitalia, but Forattini (1965) and Bram (1967) did not describe this variation. Clark-Gil and Darsie (1983) did not examine male genitalia and their key characters for females and larvae fit both *Cx. corniger* and *Cx. lactator.* Only Martinez Palacios (1950) discussed the two forms, stating that the form lacking seta *c* (i.e. *Cx. lactator*) was the more common and that it was widespread throughout the Neotropical part of Mexico.

In spite of the possibility that the differences between *Culex corniger* and *Cx. lactator* are environmentally induced (making the two forms non-genetic ecophenotypes), we believe that they are closely related, distinct species. The two collections of both species from the same larval habitat support this view. Separate species status may eventually require confirmation through crossing, rearing in artificially adjusted habitats, or chemical genetic studies. For the time being, recognition of *Cx. lactator* as a separate species will facilitate accumulation of data on this form.

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# REVIEW OF *MARICOPODYNERUS* (HYMENOPTERA: EUMENIDAE)

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*Abstract.*—The 16 known species of the genus include 7 described as new here. A key to the species is given along with illustrations of important characters. Additional locality records are included for previously described forms. New species are: *arizonicus*, Arizona, New Mexico; *differens*, Arizona, Nevada, California; *festivus*, Texas, Arizona; *linsleyi*, southern California; *lissoides*, Texas, New Mexico, Nueva Leon; *optimus*, New Mexico, Arizona; *sternalis*, California.

*Key Words:* wasps, Eumenidae, *Maricopodynerus*

H. L. Viereck described *Maricopodynerus* (1908) as a subgenus of *Odynerus* for the single new species, *maricoporum*. Bohart (1948) elevated it to generic rank and added 2 new species. Then, in a revisionary effort, Bohart (1950) added 4 more species. At that time less than 150 specimens of the genus were known. Now I have seen more than 400 and among them are 7 new species described herein. This brings the total to 16, all west of the 100th meridian in United States and Mexico.

The generic characters were given by Bohart (1950). *Maricopodynerus* is unique in its greatly enlarged, posteriorly membranous second tergum which is twice as long as the second sternum, and can enclose the remaining terga (Figs. 22–24). Specific characters of most importance are clypeal shape, punctation, and color pattern. Male genitalia are rather similar except in *sericifrons* and *arizonicus* (Figs. 17, 18).

More than one species may occur in a single locality; for example, *sericifrons* and *linsleyi* at Palm Springs, California; *rudiceps* and *decorabilis* at Boca, California; *maricoporum* and *differens* at Oak Creek Canyon, Arizona; and *lissoides* and *festivus* in Santa Elena Canyon of Big Bend Park, Texas.

Type depositories indicated with the descriptions are: Academy of Natural Sciences (San Francisco), British Museum of Natural History (London), Los Angeles County Museum (Los Angeles), University of Arizona (Tucson), University of Idaho (Moscow), Harvard University (Cambridge), University of California Bohart Museum (Davis), University of Kansas Snow Museum (Lawrence), U.S. National Museum (Washington), Oregon State University (Corvallis).

Abbreviations used are F-I etc., flagellomere; MOD, median ocellus diameter; PD, puncture diameter; T-I etc., terga; S-I etc., sterna.

## KEY TO THE SPECIES OF *MARICOPODYNERUS*

1. T-II posterior ivory band deeply u-shaped medially (Figs. 10, 12) 2
T-II posterior ivory band not deeply u-shaped medially (as in Fig. 11) .................. 3
2. Vertex swollen and partly polished behind ocelli, forewing marginal cell darkened toward apex (as in Fig. 20) ..... *arizonicus* Bohart
Vertex not swollen, punctation close and

coarse; forewing marginal cell not darkened toward apex (Fig. 21) .......... *optimus* Bohart

3. Forewing marginal cell not at all darkened toward apex .......... 4
Forewing marginal cell somewhat darkened in apical third or fourth, especially in females .......... 7

4. Tegula black and ivory or very dark red and ivory; propodeum black posteriorly or mostly so; male clypeus with black apical rim, female clypeus all black .......... *rudiceps* Bohart
Tegula light or bright red and ivory; propodeum red posteriorly; male clypeus without black apical rim; female clypeus with considerable red .......... 5

5. Forewing marginal cell unusually short and stout (Fig. 19), male F-XI stout, less than twice as long as thick in lateral profile, female clypeus all red and black .......... *sericifrons* Bohart
Forewing marginal cell more slender (shaped about as in Fig. 20 or 21), male F-XI slender, more than twice as long as thick in lateral profile, female clypeus nearly always with some ivory marks .......... 6

6. T-II with considerable red along inner margin of ivory, female pronotum mostly red dorsally, female postocular spot encircled with red .......... *chisosensis* Bohart
T-II with little or no red along inner ivory margin, female pronotum not mostly red dorsally, female postocular spot not encirlced with red .......... *maricoporum* (Viereck)

7. T-II lateral spot isolated from marginal ivory band (as in Fig. 22), male clypeus with free apical margin black rimmed (as in Fig. 5), female clypeus black with lateral ivory spot (as in Fig. 1) or all black .......... 8
T-II lateral spot attached to marginal ivory band (as in Fig. 23), male clypeus with free apical margin pale, female clypeus usually partly red but never all black .......... 10

8. T-I black except for posterior ivory band, T-II punctation rather coarse (Fig. 14) .......... *festivus* Bohart
T-I mostly or all red except for ivory band, T-II punctation unusually fine (as in Fig. 16) .......... 9

9. S-II mostly or all dark; female clypeus all black; T-II punctures small, somewhat effaced by microsculpture .......... *decorabilis* Bohart
S-II mostly or all bright red; female clypeus black with 2 white spots (Fig. 1); T-II punctures small, but their outlines distinct (Fig. 16) .......... *sternalis* Bohart

10. T-II punctation along midline in front of posterior depression absent or practically so .......... 11
T-II punctation distinct along midline .......... 12

11. T-II practically impunctate in midposterior depression, female mandible not unusually thick or bluntly curved toward apex .......... *pulvipilus* Bohart
T-II distinctly punctate in midposterior depression, female mandible thick and bluntly curved toward apex .......... *permandibularis* Bohart

12. T-II punctation coarse, rather evenly distributed, most punctures 1 PD or less apart .......... *differens* Bohart
T-II punctation fine and/or unevenly distributed with most anteromedial punctures 2 or 3 PD apart .......... 13

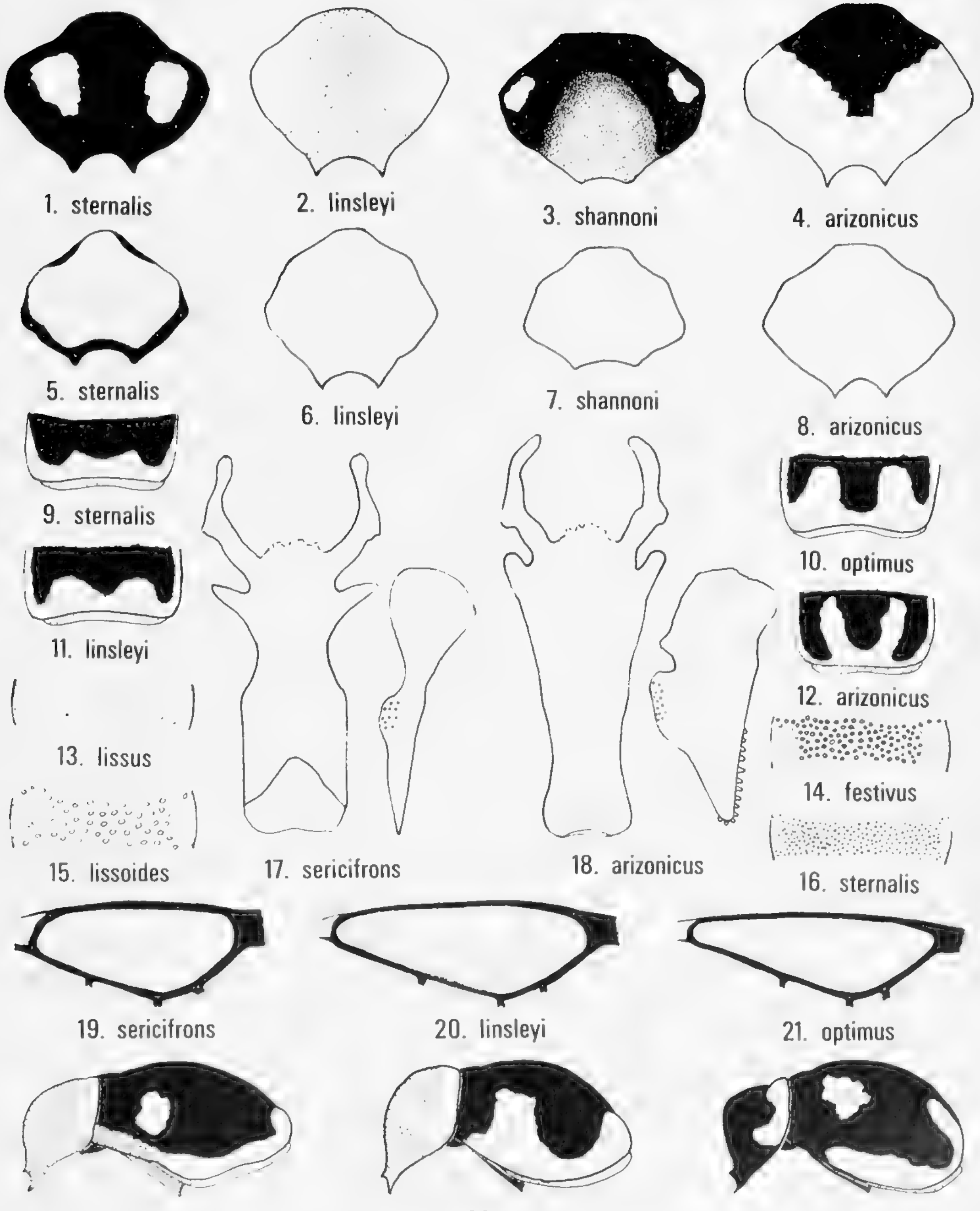
13. T-II with anterior half mostly polished in median area, punctures sparse (Fig. 13) .......... *lissus* Bohart
T-II with numerous punctures in median area (Fig. 15) .......... 14

14. T-II punctures in lateral emargination of ivory band exceptionally coarse, some almost as large as midocellus .......... *lissoides* Bohart
T-II punctures somewhat enlarged in emargination of ivory band but much smaller than midocellus .......... 15

15. Clypeus with apical emargination moderately shallow between sharp teeth (Figs. 2, 6); clypeus of male lightly microsculptured but a little shiny, that of female normally convex .......... *linsleyi* Bohart
Clypeus unusually short, apical emargination quite shallow (Figs. 3, 7); clypeus of male densely microsculptured and dull, that of female unusually flat .......... *shannoni* Bohart

## ***Maricopodynerus arizonicus*** **Bohart,**
## NEW SPECIES

Male holotype.—Length 7 mm. Black, ivory, and reddish brown. Ivory are: clypeus, dot above, ocular and postocular spots, pronotum anterodistally, 2 spots on tegula, 2 spots on scutellum, metanotal band, large upper mesopleural spot, distal spots on fore and midfemora, tibiae outwardly, irregular recurved band on T-I, markings on T-II (Fig. 24); posterolateral spot on S-II, reddish brown are: flagellum inwardly, mandible, pronotal edge posteriorly, legs mostly, central spot on tegula, terminal tergal and sternal segments; wings slightly dusky, forewing marginal cell darkened in front and on distal third. Pubescence pollinose, silvery on head and thorax, fulvous on distal third. Pubes-



1. sternalis
2. linsleyi
3. shannoni
4. arizonicus
5. sternalis
6. linsleyi
7. shannoni
8. arizonicus
9. sternalis
10. optimus
11. linsleyi
12. arizonicus
13. lissus
14. festivus
15. lissoides
16. sternalis
17. sericifrons
18. arizonicus
19. sericifrons
20. linsleyi
21. optimus
22. sternalis
23. linsleyi
24. arizonicus

Figs. 1–24. 1–4, clypeal pattern, females, × 30; 5–8, clypeal shape, males, ×30; 9–12, T-II pattern, posterior view, males, ×18; 13–16, punctation across T-II opposite lateral spot, females, ×18; 17, 18, flattened aedeagus and cuspis, ×60; 19–21, forewing marginal cell, females, 19, 20, ×40, 21, 45; 22–24, T-I-II pattern, lateral, males, ×20. Stippled areas of Figs. 2, 3, 22, 23, red.

cence pollinose, silvery on head and thorax, fulvous on T-II. Punctures moderate and sparse on clypeus, moderately coarse and close on frons, irregularly spaced across vertex, moderate and somewhat spaced on notum, pleuron and T-I, punctures of T-II moderately coarse and rather evenly spaced about a PD apart. Clypeal apex obtusely emarginate between sharp teeth (Fig. 8); F-XI small, not reaching base of IX; vertex swollen, forming a low smooth transverse swelling behind ocelli and a barely perceptible swelling near compound eye; cuspis with a row of teeth along inner edge (Fig. 18).

Female.—About as in male except: length 8 mm, clypeus more coarsely punctate and with a dark basal triangle (Fig. 4), reddish brown of legs as far as tibiae replaced by red, propodeum and T-I mostly red.

Holotype male, 5 mi w. Portal, Chiricahua Mts., Cochise Co., Arizona, VIII-7-58 (R. M. Bohart, DAVIS). Paratypes, 10 males, 21 females, topotypical, VIII-6 to VIII-22 (R. M. Bohart, SAN FRANCISCO, WASHINGTON, DAVIS). Other specimens, not paratypes, VII-IX, 6 males, 1 female, Arizona: 5 mi w. Portal, Patagonia and 6 mi se.; New Mexico: 11 mi wsw. Carrizozo, Rockhound State Park (Luna Co.), 18 mi w. Guthrie.

Discussion.—The deeply divided black markings posteriorly on T-II (Fig. 12), together with the partly polished vertex and darkened apex of the forewing marginal cell, characterize the species.

### *MARICOPODYNERUS CHISOSENSIS* BOHART

*Maricopodynerus chisosensis* Bohart 1950: 20. Holotype male, Chisos Mts., Brewster Co., Texas (WASHINGTON). The red coloration is usually extensive, bordering the ivory postocular spot and ivory band of T-II. Also, the female clypeus and pronotum are mostly red. The species is known only from Texas in Brewster Co. (type series), and 2 females in Terre Co. and Sanderson Co. (W. F. Barr, MOSCOW).

### ***Maricopodynerus decorabilis* Bohart**

*Maricopodynerus decorabilis* Bohart 1950: 22. Holotype male, Leavitt Meadows, Mono Co., California (SAN FRANCISCO).

Obviously similar to *sternalis* by its small size, less rotund T-II, and free spot on T-II, this species has the T-II punctures more shallow and partly effaced by microsculpture. Also, S-II is black instead of red. It is known from southeast Oregon and eastern California as far south as Inyo Co. Many of the 24 specimens I have seen were taken at or near Boca, Nevada Co., California on *Chrysothamnus* in July.

### ***Maricopodynerus differens* Bohart, NEW SPECIES**

Male holotype.—Length 7.5 mm. Black, ivory, and red. Ivory markings as described for *optimus* except 2 tegular spots, a distal one on midfemur, and less extensive T-II spots posteriorly; red markings as in *optimus* except propodeum laterally and posteriorly; T-I basally; forewing marginal cell darkened in apical half. Pubescence silvery, inconspicuous. Punctation as described for *optimus*, that of T-II as in Fig. 14. Clypeal apex obtusely emarginate between angular teeth, F-XI reaching base of F-IX, lateral ivory margin of T-II moderately swollen, cuspis without teeth.

Female.—About as in male: length 7.5–8.5 mm; femora all red, propodeum all or mostly red, T-I usually red except for posterior ivory band; clypeus more coarsely punctate, red and ivory or more often red, black, and ivory.

Holotype male, Oak Creek Canyon, Coconino Co., Arizona, VI-11-40 (R. M. Bohart, DAVIS). Paratypes (all DAVIS except as noted), Arizona: III-VI, 5 males, 3 females, Maricopa Mts., 4 mi s. Hoover Dam (Mojave Co., MOSCOW), 4 mi n. White River (TUCSON), Superior (TUCSON), Sedona (TUCSON), Lake Mojave; California: 2 males, 9 females, IV-VIII, Surprise Canyon and Big Pine Canyon (Inyo Co.), near Bishop and Topaz Lake (Mono Co., DAVIS, SAN FRANCISCO); Nevada: 2 males, 4 females, IV-VIII, Nelson, 5 mi e. Carson City, Mt. Montgomery, 2 mi e. Tonopah.

Discussion.—The coarse and rather evenly distributed punctures of T-II, the apically darkened forewing marginal cell, and the absence of a free spot on T-II, taken together are differentiating.

### *Maricopodynerus festivus* Bohart, New Species

Male holotype.—Length 5.5 mm. Black, ivory and red. Ivory are: clypeus except black apical rim, dot above, ocular and postocular spots, irregular anterior pronotal margin, scuttelar spots, metanotal band, anterior tegular dot, mesopleural spot, forefemoral spot, tibial streaks, posterior T-I band, T-II markings (about as in Fig. 22), apicolateral spot on S-II; red are: flagellum inwardly, tegula mostly, legs mostly (as far as tibiae); forewing marginal cell a little darkened distally. Pubescence silvery, inconspicuous. Punctures moderate on shagreened clypeus, moderate and close on frons and notum, moderately coarse and close but evenly spaced on T-I-II (as in Fig. 14). Clypeal apex obtusely emarginate between sharp teeth.

Female.—About as in male except: length 6.5 mm, clypeus black with lateral ivory spot, coarsely punctate, marginal wing cell more darkened in distal third.

Holotype male, Santa Elena Canyon, Big Bend National Park, Texas, Brewster Co., IV-9-65 (D. Bolinger, DAVIS). Paratypes, 3 females, IV-19-54 (R. H. Beamer, LAWRENCE, DAVIS); 1 female, Sabino Canyon, Santa Catalina Mts., Arizona, V-5-55 (F. G. Werner, TUCSON).

Discussion.—Although similar to *differens* in the marginal cell and punctation of T-II, there are several points of difference. In *festivus* the scape, propodeum, and basal three-fourths of T-I are black. The clypeal apex is more sharply toothed, and the female clypeus is black with 2 ivory spots. Finally, the anterior ivory spot of T-II is isolated from the lateral mark.

### *Maricopodynerus linsleyi* Bohart, New Species

Male holotype.—Length 6.8 mm. Black or dark reddish brown, ivory and red. Ivory are: same areas given for *arizonicus* except T-II spots attached laterally and posterior spots smaller (Figs. 11, 23); red are: flagellum inwardly, tegula medially, posterior edge of pronotum, legs mostly, propodeum, T-I except for ivory border; forewing nearly clear except dusky distal third of marginal cell. Pubescence as described for *arizonicus.* Punctures of clypeus small and sparse, those of frons, vertex, and notum moderately coarse and close; those of mesopleuron well separated, those of T-II moderate and about a PD apart anteriorly but becoming close beyond middle. Clypeal apex shallowly emarginate between sharp teeth (Fig. 6), F-XI moderately slender, nearly reaching base of F-IX; T-II ivory margin not overhanging membranous edge laterally; cuspis without teeth.

Female.—About as in male except: clypeus more coarsely punctate and bimaculate red and ivory (Fig. 2); anterior half of T-II with punctures usually 1–3 PD apart.

Holotype male, Palm Springs, Riverside Co., California VII-6-75, on *Dalea spinosa* (E. G. and J. M. Linsley, DAVIS). Paratypes, 11 males, 30 females, topotypical, VI-17 to VII-6 (E. G. and J. M. Linsley, SAN FRANCISCO, DAVIS); 3 males, 7 females, Corn Springs, Chuckwalla Mts., Riverside Co., California (LOS ANGELES, DAVIS); 3 males, 17 females, Shaver's Well, Riverside Co., California (LOS ANGELES, DAVIS). Other specimens, typical but not paratypes, California: Westmorland, Indio, Palm Springs, Brawley, Winterhaven (DAVIS).

Discussion.—Features of the marginal cell (Fig. 20), T-II markings (Figs. 11, 23), and clypeus (Figs, 2, 6) are given in the key. T-II is fairly well punctate but in the anterior half there are considerable polished intervals, but less so than in *lissus* (Fig. 13). Lateral punctation of T-II separate *lissoides* and *linsleyi,* which also has the clypeal apex more sharply emarginate. This last feature also distinguishes *linsleyi* and *shannoni* (Figs. 2, 3, 6, 7). The species is named for the eminent Coleopterist and Hymenopterist, my friend, E. Gorton Linsley.

### *Maricopodynerus lissoides* Bohart, New Species

Male holotype.—Length 7 mm. Black, ivory and red. Markings and pubescence as described for *linsleyi.* Punctures of clypeus small and sparse, those of frons, vertex and notum moderate and slightly separated; those of mesopleuron about 1.0–1.5 PD apart; those of T-II coarse and 1.0–1.5 PD apart on anterior half (Fig. 15), becoming closer posteriorly; those in lateral emargination of ivory band quite coarse and close. Clypeal apex weakly indented between blunt teeth, F-XI small, not reaching base of T-IX, ivory margin of T-II overhanging membranous edge laterally, cuspis without teeth.

Female.—About as in male except: length 8 mm, clypeus bicolored red and ivory and more coarsely punctate, apex nearly truncate.

Holotype male, Santa Elena Canyon, Big Bend National Park, Brewster Co., Texas, VIII-25-67 (R. Gardner, C. Kovacic, DAVIS). Paratypes, 1 male, 17 females, topotypical, VIII-22-25-54 (R. M. Bohart, SAN FRANCISCO, DAVIS, WASHINGTON); 5 males, Big Bend National Park, Texas, April (R. M. Bohart, D. Bolinger, CORVALLIS, DAVIS). Other specimens, not paratypes, 11 males, 2 females, Texas: 25 mi s. Marathon, Stillwell Crossing and Study Butte (Brewster Co.), Lajitas; New Mexico: 11 mi wsw. Carrizoza, Organ Mts., Peloncillo Mts.; Nueva Leon: near Monterrey, Mexico.

Discussion.—Differences from *linsleyi* are given under that species, and in the key.

### *Maricopodynerus lissus* Bohart

*Maricopodynerus lissus* Bohart 1950: 23. Holotype male, Maricopa Mts., Arizona (SAN FRANCISCO).

The much reduced punctation of T-II (Fig. 13) characterizes *lissus,* and the extensive smooth areas are surpassed only by *pulvipilus.* The 37 specimens I have seen came from southwest New Mexico, Arizona, and southeast California.

### *Maricopodynerus maricoporum* (Viereck)

*Odynerus* (*Maricopodynerus*) *maricoporum* Viereck 1908: 397. Holotype male, Oak Creek Canyon, Coconino Co., Arizona (LAWRENCE).

*Odynerus chelonogastrus* Cameron 1908: 202. Holotype female (no abdomen), Jerome, Yavapai Co., Arizona (LONDON). New synonymy.

This generotype species is quite similar to *lissoides* but the apically pigmented forewing marginal cell of the latter is differentiating. I have seen both types listed above and about 80 other specimens from eastern California (Inyo Co. to Imperial Co.), eastern and southern Nevada, Arizona, southern New Mexico, southwestern Texas, and southern Utah (Leeds).

### *Maricopodynerus optimus* Bohart, New Species

Male holotype.—Length 7 mm. Black, ivory, and red. Ivory are: clypeus, scape in front, ocular and postocular spots, pronotum anterodorsally, tegular spot, 2 scutellar spots, metanotal band, upper mesopleural spot, distal spot on forefemur, tibiae outwardly, irregular recurved band on T-I, markings on T-II (Fig. 10 and as in 23), subapical band on S-II; red are: flagellum weakly toward inner apex, mandible, pronotal edge posteriorly, tegula mostly, legs mostly; forewing marginal cell not darkened toward apex. Pubescence silvery, as long as 1 MOD on face and propodeum. Punctures moderate and a PD apart on clypeus, coarse and close on face and notum; punctures of T-II coarse, rather evenly distributed, mostly less than 1 PD apart, unusually coarse in lateral and posterior emarginations of ivory band. Clypeal apex obtusely emarginate between sharp teeth, F-XI reaching apical two-fifths of F-VIII, ivory margin of T-II overhanging membranous edge laterally.

Female.—About as in male except: length 8.5–9.0 mm, clypeus more coarsely punctate, black with 2 ivory spots (as in Fig. 1); pronotal band broken submedially, lateral spot of T-II sometimes unattached.

Holotype male, Dripping Spring, Organ Mts., Dona Ana Co., New Mexico (C. Townsend, WASHINGTON). Paratypes, female, New Mexico: topotypical (T. Cockerell, WASHINGTON); female, Texas: The Basin, Big Bend National Park, Brewster Co., X-4-56 (J. W. MacSwain, SAN FRANCISCO); Arizona: 2 females, Lower Madera Canyon, Santa Rita Mts., VI-I-61 (J. Bequaert, CAMBRIDGE, DAVIS).

Discussion.—The rather deeply divided ivory markings posteriorly on T-II (Fig. 10) are rivalled only by *arizonicus* which is easily separated by its somewhat bulging and polished vertex, as well as the stained forewing marginal cell.

### *Maricopodnerus permandibularis* Bohart

*Maricopodynerus permandibularis* Bohart 1948: 321. Holotype female, Tiburon Island, Gulf of California, Mexico (SAN FRANCISCO).

Known only from the type female, the stout, blunt mandibles are diagnostic. The punctation of T-II is similar to that of *lissus.*

### *MARICOPODYNERUS PULVIPILUS* BOHART

*Maricopodynerus pulvipilus* Bohart 1948: 321. Holotype male, Tortuga Island, Gulf of California, Mexico (SAN FRANCISCO).

In addition to the 6 specimens of the type series from Baja California Sur, I have before me 7 males, 7 females collected by L. D. French and E. O. Sugden 35 km s. Mulege, Baja California Sur, IV-I-80 (DAVIS). Also, there are 5 females (LOS ANGELES), 5 mi nw. San Ignacio, Baja California Sur, IX; and 13 km nw. Rosarito, Baja California, IX. The practical absence of punctation on T-II, including the posteromedial depression, is characteristic.

### *Maricopodynerus rudiceps* Bohart

*Maricopodynerus rudiceps* Bohart 1950: 21. Holotype male, Verdi, Nevada (SAN FRANCISCO).

The moderate development of the T-II ivory band posteriorly (about as in Fig. 11), even coloration of the forewing marginal cell, all-black female clypeus, and black-rimmed male clypeus will differentiate *rudiceps* from other species with close, coarse T-II punctation. This species is rather widely distributed in western United States from southeastern Washington to central Montana, south to eastern California as far as Mono Co., and in northern Arizona. I have before me several hundred specimens collected at Boca, Nevada Co., California, VII (DAVIS).

### *Maricopodynerus sericifrons* Bohart

*Maricopodynerus sericifrons* Bohart 1950: 19. Holotype male, 2 mi w. Edom, Riverside Co., California (SAN FRANCISCO).

This species can be distinguished by the clarity and stout shape of the forewing marginal cell (Fig. 19), by the limited lateral extent of the posterior membrane of T-II, and by the spade-shaped aedeagus (Fig. 17). I have seen about 80 specimens, mostly from Riverside Co., California, but a few from San Diego Co. (Borrego) and Inyo Co. (Lone Pine). Out-of-state records are from Arizona (Parker, Yuma, Wellton), and Sonora (39 mi n. Puerto Peñasco).

### *Maricopodynerus shannoni* Bohart

*Maricopodynerus shannoni* Bohart 1950: 24. Holotype male, Stratford, Washington (SAN FRANCISCO).

The short and nearly truncate clypeus (Figs. 3, 7), which is unusually flat in the female and densely microsculptured in the male, are identifying characters.

Altogether, I have seen 18 specimens. Localities are Washington (Stratford, Lake Paha), Idaho (6 mi nw. St. Anthony), Nevada (3 mi w. Hazen, Yerington), and California (Siskiyou, Shasta, Mono, and Inyo counties).

### *Maricopodynerus sternalis* Bohart, New Species

Male holotype.—Length 5.5 mm. Black, ivory, and red. Ivory are: clypeus except rim (Fig. 5), scape in front, ocular and postocular spots, pronotum anterodorsally, scutellar spots, metanotal band, tegular dots, upper mesopleural spot, small tibial spots, irregular recurved band on T-I, markings on T-II (Figs. 9, 22); lateral dot on S-II; red are: mandible apically, flagellum inside, tegula mostly, legs as far as tarsi mostly, T-I except posterior band, T-II basolateral spot, S-II mostly; forewing marginal cell darkened distally. Pubescence silvery, inconspicuous. Punctures of clypeus moderate, a little spaced by dense microsculpture; punctures of frons, vertex and notum moderate and close; those of T-II small, distinct, evenly distributed, spaced by about 1 PD of microsculpture (Fig. 16). Clypeal apex emarginate between sharp teeth (Fig. 5); F-XI small, not reaching base of F-IX; lateral ivory margin of T-II hardly swollen; cuspis without teeth.

Female.—About as in male except: length 6.5 mm, clypeus black with 2 ivory spots (Fig. 1), pronotal band broken submedially, tegula all red.

Holotype male, Townes Pass, Inyo Co., California, V-6-60 (A. S. Menke, DAVIS). Paratypes, 2 females, California: 12 mi s. Baker, IV-15-69 (E. E. Grissell, DAVIS); Argus Mts. (Inyo Co.), V-22-37 (N. W. Frazier, DAVIS).

Discussion.—The similar shape and markings of T-II indicate a relationship to *decorabilis*. However, in *sternalis* the maculate rather than all black clypeus (Fig. 1), mostly red rather than black S-II, and finely but distinctly punctate T-II, indicate a different species.

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# DRUMMING BEHAVIORS OF THREE PENNSYLVANIA STONEFLY (PLECOPTERA) SPECIES

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*Abstract.*—Drumming behaviors of three central Pennsylvania stonefly species were described. Males of *Tallaperla maria* initially produced calls of a single scraping beat which shifted to a two-pulse scrape/beat call as signal exchanges with females continued. *Agnetina capitata* males produced a diphasic call that is the longest known in any stonefly species. The signals of *T. maria* and *Pteronarcys biloba* were compared to previous signal descriptions from geographically separate populations, and some intraspecific divergence of signal structure was found in these species.

*Key Words:* Plecoptera, stoneflies, drumming behavior, reproductive behavior, *Tallaperla, Pteronarcys, Agnetina*

Drumming behavior in stoneflies is a system of intersexual vibrational communication which aids in mate identification and location. The vibrational pulses that make up signals are typically produced when the insects strike or scrape the substratum with the posteroventral portion of the abdomen (Rupprecht 1967, Maketon and Stewart 1984). Drumming behavior was first quantified by Rupprecht in 1967. To date, numerous workers have described the signals of over 100 species (see Zeigler and Stewart 1987, Maketon and Stewart 1988 for literature citations). Continued descriptive work of this nature contributes to systematics (Zeigler and Stewart 1987) and to data banks which may help answer other assorted evolutionary questions, such as those raised by the current hypotheses concerning sexual selection's role in the divergence of reproductive behaviors (West-Eberhard 1984, Searcy and Andersson 1986). To elucidate these and other evolutionary implications, more species and various populations within species must be studied. The present work describes drumming in three North American stonefly species and suggests some divergence of drumming between intraspecific populations.

## MATERIALS AND METHODS

Virgin adults of two of the three species were obtained by rearing pre-emergent nymphs in styrofoam bait buckets. The nymphs were collected as follows: *Tallaperla maria* (Needham & Smith), Fisher Run, Columbia Co., PA, 12-V-1987; *Pteronarcys biloba* Newman, Fishing Crk., Columbia Co., PA, 18-V-1987. The adults of *Agnetina capitata* (Pictet) were collected in early May 1987 along the banks of the Susquehanna River at Danville, PA (Montour Co.). The presence of numerous emergent exuviae along the riverbank showed that *A.*

*capitata* nymphs were emerging from the Susquehanna and not from any nearby feeder streams.

All adults were allowed to adjust to lab temperature for at least one hour prior to recording. Drumming exchanges were recorded in stereo (male and female on separate channels) on cassette tapes using a recording setup similar to that described by Zeigler and Stewart (1985). All recordings of *T. maria* and *P. biloba* were of adults one to three days old. Signals were measured and analyzed using a Tektronix 5111 storage oscilloscope, and selected signals were photographed with a Nikon FG SLR camera.

## Results and Discussion

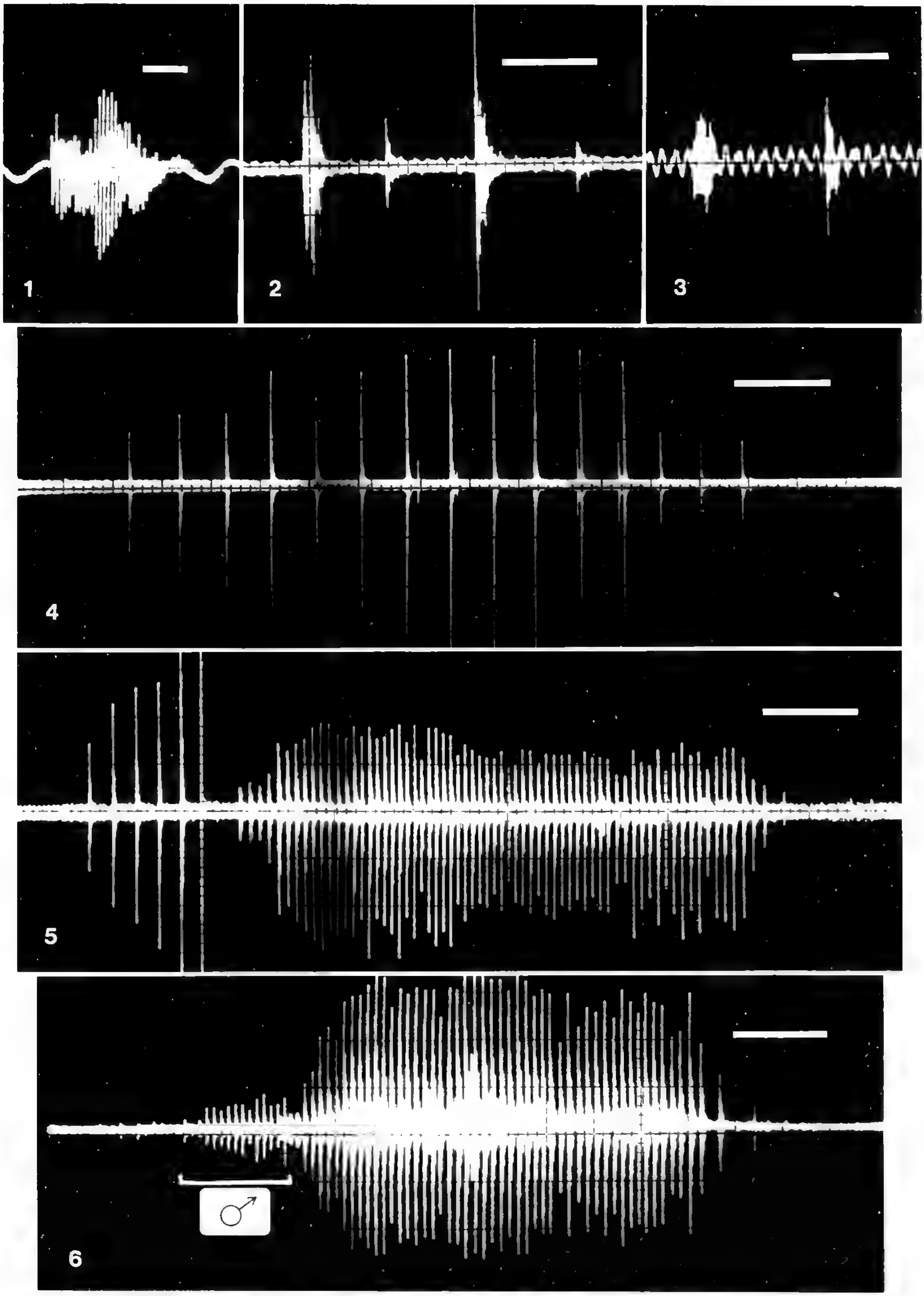
*Tallaperla maria.*—At 19–20°C males (n = 7) produced calls of a single scraping beat. Observations indicated that the scrapes were produced by curling the abdomen anteroventrally to contact the substratum and then straightening the abdomen posteriorly thus scraping the abdomen tip across the substratum. The male's body rocked slightly in the posterior direction as the scrape was produced. The scrape tone averaged 596 ± 86 Hz with a duration of 47 ± 10 ms as measured on the oscilloscope screen (Fig. 1). However, scrape duration could have been less, because the residual ringing was impossible to distinguish from the scrape itself on oscilloscope tracings. When unanswered by a receptive female, male scrapes (calls) usually occurred in series of three to five calls. Within such a series, calls were separated by 1379 ± 175 ms.

Females (n = 5) produced answers consisting of a single abdomen/substratum beat which followed the male call after 178 ± 21 ms. After one to three of these simple exchanges, the males added a response scrape 190 ± 11 ms after the female's answer, and later exchanges evolved into four-part exchanges with a male call, female answer, male response, and female "response" (Fig. 2). In one pair, the male response was a simple beat rather than a scrape.

In three of the five pairs, the male switched to a different type of call in later exchanges within an exchange series. This call consisted of the initial scrape followed by a simple beat (Fig. 3). The scrape/beat interval was 245 ± 25 ms and the female answer typically followed in 181 ± 9 ms. In two of the five pairs, scrape/beat calls initiated a few three-part and even four-part exchanges as described above, but the majority of later exchanges consisted only of a male scrape/beat call and a female answer. Females were typically stationary between exchanges while males searched when not signalling.

Maketon and Stewart (1988) describe five "calls" from three males of another *T. maria* population in southwestern Virginia. They interpret the call as consisting of a series of scrapes similar to those noted for the Pennsylvania males when females were not answering. It seems likely that these Virginia calls were really a call series similar to those noted herein which would have broken down into single scrape calls if females had answered. Single scrape calls are described for *T. lobata* and *T. anna,* and another call series described in *T. elisa* (Maketon and Stewart 1988). Since no male/female exchanges were recorded for these species, it is impossible at this time to say if the scrape/beat calls produced by the Pennsylvania males late in exchange series are unique to this species or population. The intercall intervals in the call series of the Virginia population appear distinctly shorter than those noted for the Pennsylvania population (app. 450 ms vs. 1379 ± 175 ms, respectively) even allowing for the 4°C warmer recording temperatures for the Virginia population (see Zeigler and Stewart 1977 regarding drumming speed and temperature).

*Pteronarcys biloba.*—At 20°C, males (n = 4) produced calls of 12.5 ± 1.5 beats with beat intervals which were close to constant at 944 ± 53 ms. Only two answers from one female were recorded. These answers contained 9.5 ± 0.7 beats with relatively constant intervals of 869 ± 48 ms. These



Figs. 1–6. Oscillographs of drumming signals. 1, *Tallaperla maria*, male scrape call at 20°C (20 ms)*. 2, *Tallaperla maria*, four-part exchange at 20°C (200 ms)*. 3, *Tallaperla maria*, male scrape beat call at 20°C (200 ms)*. 4, *Pteronarcys biloba*, overlapping male female exchange at 20°C (1st female beat is seen after 7th male beat, some male and female beats overlap) (2000 ms)*. 5, *Agnetina capitata*, diphasic male call at 21°C (1000 ms)*. 6, *Agnetina capitata*, reinforcement event at 21°C (1000 ms)*. *Time indicated by white bar in upper right corner.

answers overlapped the male calls by five to six beats (Fig. 4). The overlap of call and answer is a relatively common occurrence in the genus *Pteronarcys* (Zeigler and Stewart 1987).

Stewart et al. (1982) describe drumming in a Tennessee population of *P. biloba.* They report a male call of seven to eight beats with beat intervals of 524 ± 46 ms. Recording temperature was not reported for the Tennessee population, so there is no way to guess whether a significant difference exists between the two populations in beat spacing. The difference in the number of beats per call seems significant (TN = 7.17 ± 0.8; PA = 12.5 ± 1.5), but the Tennessee data, taken from only one male, is insufficient for drawing a conclusion.

*Agnetina capitata.*—At 21–22°C six of seven males produced diphasic calls with 9.2 ± 2.6 beats in the first phase (Fig. 5). Within the first phase, beat intervals decreased from 256 ± 12 to 203 ± 22 ms. The interphase interval was 123 ± 19 ms. The second phase consisted of 68.9 ± 43.3 beats with intervals averaging 100 ± 14 ms, but typically starting and ending intervals averaged 110–120 ms while the central body of this phase consisted of 80–90 ms intervals. This diphasic call, which ranged up over 150 beats, is the longest male call, in terms of beat number, ever described in stoneflies.

One male produced monophasic calls that were indistinguishable from the first phase of the other six males' calls. This shortened call could have resulted because, in the initial exchange, the female answered before even this "first phase" was completed. Perhaps the male simply aborted his second phase due to the female's "premature" answer. The female also answered "early" in the second exchange, but not in the third and fourth where the male also delivered only a first phase type call. The longest calls recorded from other males (197 and 170 beats) were unanswered calls. It appears that males may stop signalling when the female initiates her answer, otherwise delivering a longer call.

Females (n = 3) produced long answers of 185.4 ± 36.9 beats with relatively constant beat intervals of 82 ± 3 ms. Answers typically overlapped the last few beats of the male call. In two of three pairs, exchanges continued beyond the call and answer with what I am terming "reinforcement events." The male would overlap or follow closely the end of the female's answer with 12.9 ± 0.8 beats with intervals varying widely around 100 ms. These male beats would stimulate more female drumming in groups of 29.8 ± 11.4 beats with beat intervals similar to those in her answer. Reinforcement events (Fig. 6) usually numbered three to four per exchange and overlapped the previous event or followed after a pause of less than two seconds.

In the third pair, the male produced a signal of 121 ± 12.2 beats which overlapped or shortly followed the female's answer and terminated the exchange. Beat intervals in this signal were similar to those in the second phase of the call but with slightly longer beat intervals starting and ending this series. In two of the three pairs, males delivered a few (less than five) irregularly spaced "reinforcement beats" during the last half of the female's answer. These beats were delivered on the move (i.e. males did not cease their searching movements to produce these beats). The females remained stationary during and between exchanges. Males searched when not signaling, especially during the long female answers which could last as long as 25 seconds.

Maketon and Stewart (1984) and Graham (1983) report on drumming in populations of *Agnetina capitata* in Oklahoma and Wisconsin respectively. However, after a recent genus revision by Stark (1986), both previous studies were found to be on *A. flavescens* (K. W. Stewart and S. W. Szczytko personal communication). The present descriptions, then, are the first for *A. capitata.* Males in both populations of *A. flavescens* produced a much shorter monophasic call. Since monophasic calls are generally believed to be the plesiomorphic condition (Zeigler and Stewart 1987), the extraordinary length and diphasic nature of the *A. capitata* calls appear to be apomorphic within the genus, although diphasic calls have apparently arisen separately in other genera and families (Zeigler and Stewart 1987). The reinforcement events noted above may likewise be apomorphic additions since they were not seen in the Oklahoma *A. flavescens* (no live male/female exchanges were recorded in the Wisconsin population), but conversely they could represent a shorter ancestral exchange with the initial diphasic call and long female answer being the apomorphic additions.

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# LONGEVITY, FERTILITY, AND POPULATION GROWTH STATISTICS OF *TELENOMUS REYNOLDSI* (HYMENOPTERA: SCELIONIDAE)

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*Abstract.*—Longevity and fertility of female *Telenomus reynoldsi* Gordh and Coker parasitizing *Geocoris punctipes* (Say) eggs were determined at constant temperatures of 20, 25, 28 and 32°C. Females lived significantly longer at temperatures below 32°C, but produced significantly more offspring at 28°C. Net reproductive rate was greatest at 25 and 28°C, whereas intrinsic rate of increase was highest at 28°C. Population growth statistics are compared to those of *G. pallens* Stål.

*Key Words:* *Geocoris pallens, Geocoris punctipes,* sex ratio, net reproductive rate, intrinsic rate of increase

Big-eyed bugs, *Geocoris* spp., are common predaceous lygaeids in many agroecosystems of the western and southern United States. Nymphs and adults consume immature stages of several crop pests (Champlain and Sholdt 1967, Ables et al. 1978, Lawrence and Watson 1979, Crocker and Whitcomb 1980, McDaniel et al. 1981, Ragsdale et al. 1981). For this reason, big-eyed bugs may be an important component of pest management programs.

The scelionid *Telenomus reynoldsi* Gordh and Coker is a solitary endoparasitoid of big-eyed bug eggs. Distribution of the parasitoid extends throughout the southern United States from California to Florida. Egg parasitism may range up to 65% in southern California cotton (Coker 1973) and Alabama cotton and soybean fields (Cave and Gaylor 1988b). Thus, *T. reynoldsi* may limit the impact big-eyed bugs may have in pest management programs.

Information concerning reproductive capabilities and longevity of *T. reynoldsi* is useful for evaluating the potential impact of this parasitoid on big-eyed bug populations. Nevertheless, little work has been done on these aspects of the adult biology of the parasitoid. Coker (1973) reported the fertility of 10 females at 27°C ranged from 47 to 107 progeny per female. He also found that adult longevity decreased with an increase in temperature from 16 to 32°C and increased when adults were provided with honey or with honey + water.

This paper presents the results of a study of longevity and fertility of *T . reynoldsi* parasitizing *G. punctipes* (Say) at four constant temperatures. Population growth potential of the parasitoid is described by four population growth statistics calculated for each temperature. These statistics are compared to those of another big-eyed bug, *Geocoris pallens* Stål (Tamaki and Weeks 1972), since population growth statistics are not available for *G. punctipes.*

## METHODS AND MATERIALS

Parasitized *G. punctipes* eggs from a laboratory colony (Cave et al. 1987) were ran-

Table 1. Reproductive statistics of *Telenomus reynoldsi* at four constant temperatures.

| Variable | Temperature | | | |
|---|---|---|---|---|
| | 20°C | 25°C | 28°C | 32°C |
| *n* | 21 | 20 | 20 | 20 |
| Adult female longevity ($\bar{x}$ ± SE) | 17.7 ± 0.6a | 16.8 ± 0.8a | 17.0 ± 0.8a | 12.4 ± 0.6b |
| Mean number progeny produced ($\bar{x}$ ± SE) | 14.1 ± 1.2c | 39.0 ± 3.5b | 51.9 ± 5.2a | 41.1 ± 2.8b |
| Sex ratio (M:F) | 1.5:1a | 1.5:1a | 1.6:1a | 3.7:1b |
| Net reproductive rate (♀♀/♀) | 4.3 | 10.7 | 10.5 | 1.7 |
| Generation time (days) | 35.3 | 21.0 | 16.1 | 13.1 |
| Intrinsic rate of increase (♀♀/♀/day) | 0.042 | 0.117 | 0.152 | 0.043 |

Means within rows followed by the same letter are not significantly different ($P > 0.05$; Duncan's multiple range test and $\chi^2$ test of homogeneity of proportions).

domly assigned to controlled environment chambers and reared under constant temperatures of 20, 25, 28, or 32°C and a 14:10 L:D photoperiod. On the morning of eclosion, adult *T. reynoldsi* females were transferred individually to plastic cups (30 ml) containing 10–15 *G. punctipes* eggs <72 h old and returned to the temperature and photoperiodic regimen in which they were reared. Each female was accompanied by 1–2 males. A drop of honey-water was applied to the inside of each cup as a food source. Each female was checked daily for survival and, if alive, transferred to a new cup containing fresh hosts and food. Dead males were replaced with live ones. A water-saturated cotton ball was placed in the cup containing the exposed eggs and the eggs were incubated at 28°C in a rearing room. After 5 days, parasitized eggs were counted, separated from unparasitized eggs (Cave and Gaylor 1988a), and held for adult emergence. The sex of each emerging adult was determined. Hosts with parasitoids which failed to emerge were dissected and the sex of the parasitoid was determined if possible.

Effects of temperature on female longevity and fertility were analyzed using the GLM procedure of the Statistical Analysis System (SAS 1985) and means were separated with Duncan's multiple range test. The sex ratios of offspring produced at the different temperatures were separated using a $\chi^2$ test of homogeneity of proportions. Each adult female was considered a separate replicate.

A survivorship and fertility table was constructed for wasps held at each of the four experimental temperatures by determining for each day (x) the proportion of surviving individuals ($l_x$) and the mean number of daughters per surviving female ($m_x$). The survivorship level at adult emergence was set as equal to the survivorship level previously determined for the end of the immature stage (Cave and Gaylor 1988a). From the survivorship and fertility tables, the following population growth statistics were calculated: $R_0$, the net reproductive rate, is

$$\sum l_x m_x \tag{1}$$

for all age intervals; G, the mean generation time, is

$$\sum l_x m_x x_p / R_0 \tag{2}$$

where $x_p$ = pivotal age, which includes the mean developmental time of an immature female at the particular temperature (Cave and Gaylor 1988a); and r, the intrinsic rate of increase, is determined by substituting values for r into the equation

$$\sum l_x m_x e^{-rx_p} = 1 \tag{3}$$

until equality is obtained.

## RESULTS AND DISCUSSION

Longevity.—Mean longevity of adult female *T. reynoldsi* was significantly ($F = 11.3$; df = 77; $P < 0.05$) shorter at 32°C than at

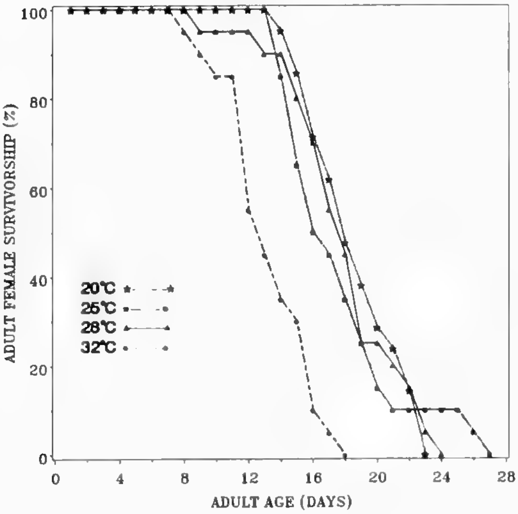

Fig. 1. Age-specific survivorship of adult female *Telenomus reynoldsi* at four constant temperatures.

the other three temperatures (Table 1). Maximum adult longevity at 20, 25, 28, and 32°C was 22, 26, 23, and 17 days, respectively (Fig. 1). Coker (1973) determined mean longevity of adult females at 16, 21, 27, and 32°C to be 34.6, 23.1, 20.3, and 17.2 days, respectively.

Survivorship at 20, 25 and 32°C was 100% until nearly one-half or more of the maximum adult age (Fig. 1). Survivorship at 28° was 100% until only one-third of the maximum adult age. Survivorship decreased steadily after these periods until the last female died, except at 25°C where two females lived 5 and 6 days longer than the third oldest female.

Fertility.—Mean number of progeny per female was significantly ($F = 21.8$; df = 77; $P < 0.05$) greater at 28°C than at the other three temperatures (Table 1). Fertility at 20°C was significantly less than at 25, 28, and 32°C. The most progeny produced by a single female at 20, 25, 28, and 32°C was 22, 80, 99, and 65, respectively. Coker (1973) reported an average of 79.1 offspring per female at 27°C; the maximum for a single female in his study was 107. More male than female offspring were produced at each temperature (Table 1). The sex ratio was significantly ($\chi^2$ test of homogeneity of proportions; $P < 0.05$) more skewed towards males (79%) at 32°C than at the three cooler temperatures. Since fertility at 32°C was not significantly different from fertility at 25°C, we concluded that the high proportion of males produced at 32°C may have been due to sperm inviability, which would have caused unfertilized eggs to become males. Also, different temperatures may unequally affect mating activity, which ultimately affects sex ratio. Sex ratios in the field are 1:1 or slightly skewed towards males (Cave and Gaylor 1988b). Contrary to our findings, Coker (1973) found that female progeny outnumbered males 3 to 2. The difference in sex ratio between our laboratory findings and those encountered in the field and those found by Coker may be influenced by laboratory conditions, such as colony density.

The fertility of *T. reynoldsi* is comparable to that of other species of *Telenomus.* Yeargan (1982) found that the mean number of progeny/female *Telenomus podisi* Ashmead was ca. 40 at 21°C. Orr et al. (1986) reported the fertility of *Telenomus calvus* Johnson was ca. 22 offspring/female at 27°C and that ca. 32 offspring/female were produced by *Telenomus cristatus* Johnson. Conversely, Schwartz and Gerling (1974) observed that *Telenomus remus* Nixon produced ca. 165 offspring at 25°C, although females lived only nine days. A species that parasitizes hosts in dense patches, such as *T. remus* attacking egg masses of *Spodoptera* spp., might take advantage of high host abundance by producing large numbers of progeny at one time. However, species attacking smaller egg masses (e.g. the pentatomid egg parasitoids, *T. podisi, T. cristatus,* and *T. clavus*) or widely dispersed solitary hosts (e.g. *T. reynoldsi*) might have lower fertility if they expend more energy reserves for host searching and less for egg production.

Daily production of progeny by *T. reynoldsi* was highest during the first five days of adult life at 25, 28, and 32°C (Fig. 2). At

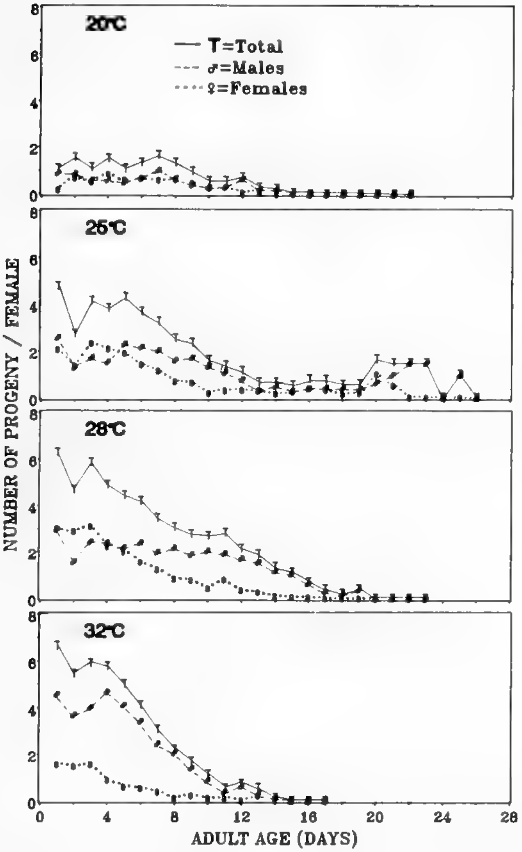

Fig. 2. Age-specific fertility of female *Telenomus reynoldsi* at four constant temperatures.

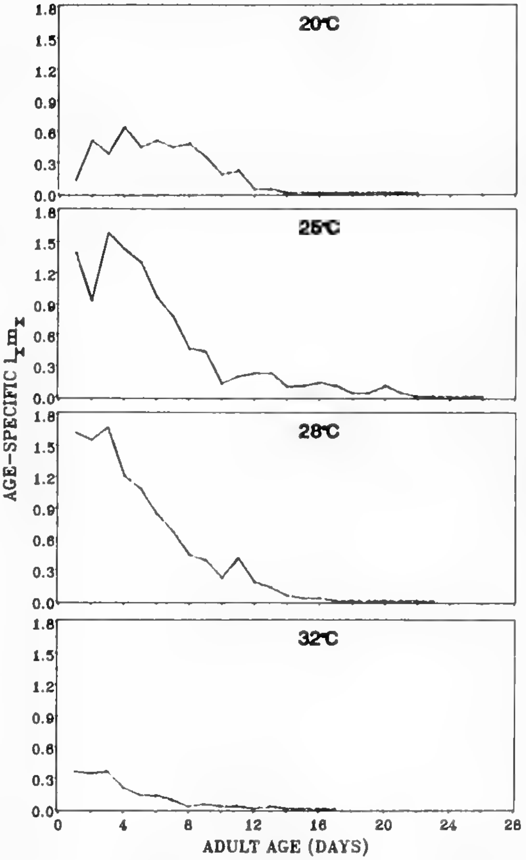

Fig. 3. Age-specific $l_x m_x$ values of female *Telenomus reynoldsi* at four constant temperatures.

28 and 32°C, fertility gradually declined after five days, but at 25°C it stabilized for seven days after declining for seven days. As reflected in the lifetime sex ratios, male progeny outnumbered female progeny on most days.

Most females oviposited within 24 h after emerging from their host. At temperatures ≥25°C, ca. 96% oviposited during the first day. At 20°C, ca. 63% of the females did not oviposit on day 1, and three did not oviposit during the first three days. Coker (1973) determined the preoviposition period of *T. reynoldsi* to be less than 6 h at 27°C.

Mean (±SE) number of days to completion of oviposition was 10.7 (±0.6), 12.8 (±0.9), 13.8 (±0.7), and 9.8 (±0.5) for 20, 25, 28, and 32°C, respectively. Maximum oviposition period was 15, 25, 19, and 14 days, respectively. Some females lived for several days after their last day of oviposition. Mean (±SE) postovipositional period was 6.5 (±0.9), 3.9 (±0.5), 3.2 (±0.5), and 2.6 (±0.4) days at 20, 25, 28, and 32°C, respectively. Yeargan (1982) reported that *T. podisi* also lived ca. 5 days after completion of oviposition.

Population growth statistics.—The reproductive contribution of each adult female age-class is represented by the product of age-specific survivorship and age-specific production of daughters ($l_x m_x$) as a function of age (x) (Fig. 3). At 25 and 28°C, the curves are similar, with the earliest ages contributing most (i.e. $l_x m_x$ values highest). Ages

2–8 contributed the most at 20°C. At 32°C, $l_x m_x$ values were highest the first few days, but were still as low as 25% of those at 25 and 28°C because of lower survivorship and fewer female progeny at 32°C.

Net reproductive rates ($R_o$) at 25 and 28°C were similar and more than 2- and 6-fold those at 20 and 32°C, respectively (Table 1). Mean generation time (G) decreased with increasing temperature. The mean generation time at 20°C was more than 2-fold that at 28 or 32°C. The intrinsic rate of increase (r) was highest at 28°C and lowest at 20 and 32°C. The intrinsic rates of increase convert to doubling times (ln 2/r) of 16.9, 5.9, 4.6, and 16.1 days. Although immature parasitoids develop fastest at 32–33°C (Cave and Gaylor 1988a), reduced survival of immatures, shortened lifetime, and low production of daughters at this temperature limit the population growth potential.

Population growth statistics have been estimated for only two other species of *Telenomus*. Hirose (1986) calculated an $r_0$ of 0.296 females/female/day at 30°C for *Telenomus dendrolimi* Matsumura attacking the eggs of the pine moth, *Dendrolimus spectabilis* Butler. Orr et al. (1986) found that the intrinsic rate of increase of the phoretic pentatomid egg parasitoid *T. calvus* at 27° was 0.149 females/female/day, which is similar to that found for *T. reynoldsi* at 28°C.

Population growth statistics have not been estimated for *G. punctipes*. However, these statistics have been determined for *G. pallens* and *Geocoris bullatus* (Say) (Tamaki and Weeks 1972). *Geocoris pallens* is a known host of *T. reynoldsi* (Gordh and Coker 1973), but parasitism of *G. bullatus* eggs has not yet been demonstrated. The net reproductive rate (26.8 females/female) and generation time (59 days) of *G. pallens* are more than twice those of *T. reynoldsi* at 25° and 28°C. The intrinsic rate of increase of *G. pallens* was 0.056 females/female/day, which converts to a doubling time of 12.3 days. These population growth statistics suggest that, although the host produces twice as many daughters as the parasitoid, the parasitoid has greater population growth potential due to its shorter generation time and faster intrinsic rate of increase. However, as pointed out by Tamaki and Weeks (1972), *Geocoris* species may have quite different population growth statistics with different diets and physical conditions, and these conditions may at times favor the host.

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# LIFE HISTORY OF *PTEROMALUS COLORADENSIS* (ASHMEAD) (HYMENOPTERA: PTEROMALIDAE) A PARASITE OF *PARACANTHA GENTILIS* HERING (DIPTERA: TEPHRITIDAE) IN *CIRSIUM* THISTLE CAPITULA

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*Abstract.*—The biology and behavior of *Pteromalus coloradensis*, a solitary larval-pupal parasite of *Paracantha gentilis*, a thistle-capitulum-infesting tephritid, are described. *Pteromalus coloradensis*, previously known from a single female collected in Colorado, is reported herein from California. We describe larval and pupal development using laboratory reared specimens, and oviposition, feeding, and reproduction from field and laboratory observations. Scanning Electron Microscopy of adult mandibles was used to determine the function of the dentition during emergence from the host puparium and overwintered capitula. Morphometric analysis of individual host puparia and parasites showed three distinct relationships between size and sex of the parasite to the size of the host puparium, substantiating predetermination of sex by the ovipositing female. Courtship behavior and the side mounting of the female by the male during copulation have not been previously described for males in *Pteromalus*. A description of the male is given.

*Key Words:* Insecta, *Paracantha*, *Cirsium*, *Pteromalus*, parasite, functional morphology, courtship behavior

This study of *Pteromalus coloradensis* (Ashmead) was undertaken while working on the life history of its host, *Paracantha gentilis* Hering, a stenophagous capitulum-infesting tephritid on *Cirsium* thistle species in western North America (Foote and Blanc 1963, Goeden and Ricker 1986a, b, 1987a, b). Ashmead (1890) described *Pteromalus* (= *Rhopalicus*) *coloradensis* from one female specimen taken at West Cliff, Colorado; no rearing records were given. Rare is the opportunity to describe the life history of a parasite, but *Pt. coloradensis* lent itself well to study, thus we were able to obtain as complete a record of its biology and behavior as known for any other North American species in this family.

## Materials and Methods

*Cirsium californicum* Gray capitula containing host puparia were collected from Mill Creek, San Bernardino National Forest, San Bernardino Co., California, 16 km N.E. of Mentone, and *Cirsium proteanum* J. T. Howell capitula were collected from Sawmill Mt., Angeles National Forest, Los Angeles Co., California, 25 km S.E. of Gorman, during the Spring and Summer of 1987 and 1988 (Headrick and Goeden 1990). The capitula were dissected to remove the host puparia which were then individually placed in 60-ml clear plastic rearing vials. Newly emerged adults of *Pt. coloradensis* were maintained on a diet of honey which was streaked onto the inside of the vials. Couples, consisting of virginal males and females, were placed together in a vial to observe courtship and copulatory behavior. The larvae and pupae were placed onto moistened filter paper in covered glass petri dishes and held in darkened growth chambers at 27°C to determine developmental rates.

Specimens for Scanning Electron Microscopy were killed by freezing, then either air-dried or fixed in osmium tetroxide for 24 h (Sabatini et al. 1963), and finally placed on stubs and sputter-coated with a gold-platinum alloy. The SEM used was a JOEL-JSM-35C3 in the Department of Nematology, University of California, Riverside. Specimens were examined and micrographs prepared at 15 kV accelerating voltage on Polaroid 55 P/N film. All micrograph negatives are stored with Gordon Gordh, Department of Entomology, University of California, Riverside. Voucher specimens of *Pteromalus coloradensis* from this study are deposited in the research collection of RDG and the United States National Museum of Natural History for incorporation into the Chalcidoidea collection.

## RESULTS

Biology.—New California records. San Bernardino Co.: Mill Creek, 16 km N.E. of Mentone on State Hwy. 38, San Bernardino Nat. Forest, 14 F, 16 M, ex. *Pa. gentilis* on *C. californicum* 25-IV-87 to 14-VI-88 (D. Headrick, UCR). Los Angeles Co.: Sawmill Mt., 25 km S.E. of Gorman at Sawmill campground, Angeles Nat. Forest, 10 F, 5 M, ex. *Pa. gentilis* on *C. proteanum* 29-VII-87 (D. Headrick, UCR).

Immature stages.—*Pteromalus coloradensis* is a solitary, larval-pupal endoparasitoid. The egg is laid within the host during the larval stages, but the host continues its development through pupariation. Dissections revealed that parasite larvae completely consumed the pupa within the puparium only after the completion of pupariation. However, three (5%) of 60 puparia taken from post-blossom capitula of *Cirsium proteanum* contained parasite larvae that fed on the late pupal stage of the host, leaving an empty, unemerged host pupa inside the puparium. Normally, however, the overwintered larva consumed the entire contents of the host and used the hollowed puparium for its own pupation.

The last instar larva pupated with its head directed anteriorly inside the host puparium beginning in February in both the field and the laboratory. Pupal development lasted 3 to 4 days under insectary conditions. Four partly opened host puparia containing last-instar parasite larvae were held in darkened growth chambers and observed every 12 h during pupation. Within the first 24 h, the larva developed into an opaque white pupa resembling the size and shape of the adult and which could be sexed (there were three males and one female). After 36 h, the head and mesosoma became iridescent green while the metasoma distad of the propodeum remained white. After 60 h, the male metasoma had completely turned an iridescent green; however, the female sterna remained unpigmented and the gonopore and unsclerotized ovipositor could be seen rhythmically pumping ca. once per second. The antennae and legs of individuals of both sexes were observed moving within the confines of the pupal integument. After 72 h, the female's first-four sterna distad from the propodeum became an iridescent green, and the ovipositor was sclerotized to a golden color. The antennae and legs moved more rapidly than previously was observed and showed twisting movements, the mesosoma swelled every 5 to 10 min. The males emerged before 84 h had elapsed and the female emerged later after 94 h.

Adult.—Host puparia (n = 82) dissected from capitula of *C. californicum* and *C. proteanum* were caged individually in ventilated rearing vials and held in the insectary at constant conditions; 11 (13%) parasites emerged within 1 month. From three of the puparia obtained from *C. californicum* heads

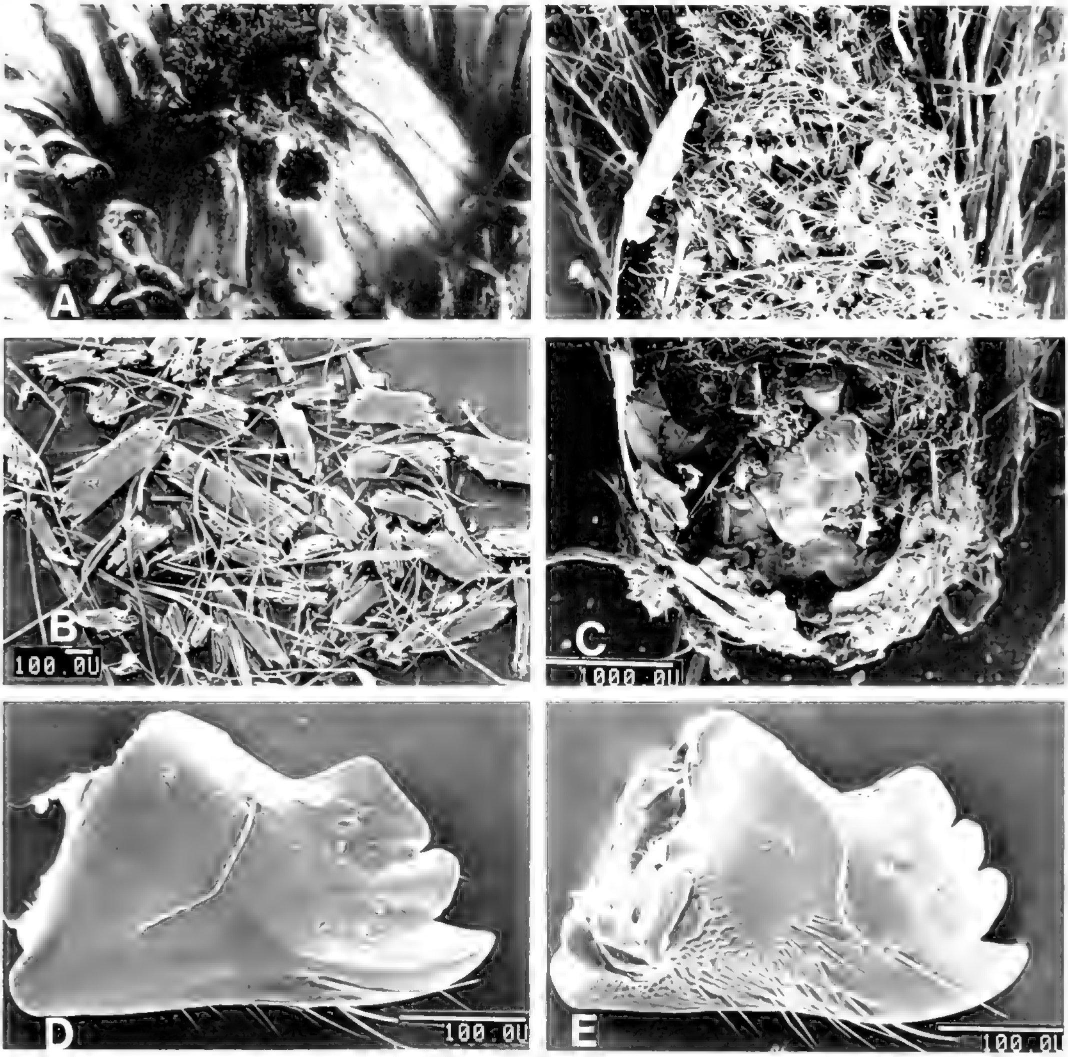

Fig. 1. (A) Emergence hole in over-wintered head of *C. californicum*. (B) Catacord. (C) Catacord in dissected host puparium. (D) Inside surface of left mandible. (E) Outside surface of right mandible.

caged on 9-VI-1987, parasites first emerged on 11-II-1988 after 8 months in the insectary. Adults emerged between 7-II to 9-III-1988, from overwintered heads collected on 3-II-1988 at the Mill Creek site. Emergence from overwintered heads in the field began on 12-III-1988. Males emerged first, and after a week, females began to appear. Field observations and laboratory rearings suggested that a portion of the first generation of the parasite population emerges in summer and parasitizes the last of the current host generation. The remainder of the first generation as well as this second generation of parasites overwinters in puparia within closed capitula and presumably emerges the following spring.

Adults exit the host puparium by chewing a small, circular hole near the anterior end, but never at the apex. They exit the capitulum by chewing a tunnel through the dried floral tubes, pappus and bracts of the overwintered head (Fig. 1A). As the emerging parasite adult progresses through the head, the chewed material, here given the name "catacord" (Fig. 1B), is systematically packed into the empty puparium (Fig. 1C).

The mandibular structure was viewed with the SEM to determine the method of excision and cutting of the catacord. In this genus there can be a difference in dentition between left and right mandibles, e.g. in *Pt. coloradensis* the right has four teeth and the left has three teeth in both sexes (Fig. 1D, 1E). The dorsal tooth has a broad, chisel shape and a sharp leading edge. The left dorsal tooth is twice as broad as the right. The middle teeth are rounded with sharp leading edges. Both mandibles have a ventral tooth which is elongate, conical and tapers to a point apically. The emerging parasite faced two very different substrates through which it had to chew. The first obstacle was the puparium which was hard, concave, and without much surface texture (Headrick and Goeden 1990). The two ventral teeth punctured the wall of the puparium and then were brought together to make a cut. The parasite continued to cut a circular hole, until eventually the excised piece of shell was freed, then pushed down into the bottom of the puparium. The next obstacle was the dried capitulum tissues consisting of floral tubes and compact fibers of pappus. As the parasite exited the puparium, it chewed through the capitulum at an angle perpendicular to the fibers. By lifting its head, the plane of the cutting teeth was in a position to grasp and cut through the fibers. The uniform width of the catacord is thus defined by the limit of mandible extension and the tunnel diameter is a function of the degree of rotation of its head.

Orientation of exit holes in capitula lying on the ground, remaining on upright plants or in rearing vials was always the same regardless of the positions of the capitula (Fig. 1A). Capitula stored in darkened rooms over the winter and later dissected showed that most parasites had tunneled within the head in various directions but did not exit. Thus, perception of increasing light intensity may help guide successful emergence from a capitulum.

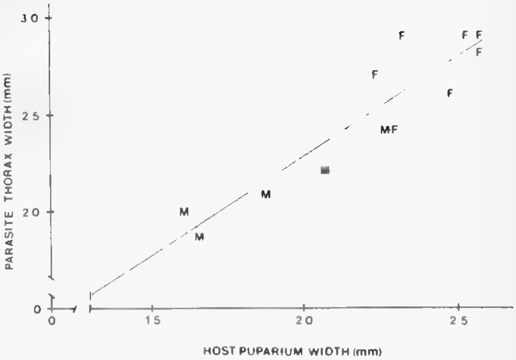

Fig. 2. The relationships of the parasite thorax width at its widest point and the host puparium width at its widest point. F, female; M, male; (central M·F, represents a shared data point).

Three relationships between the maximum width of the parasite thorax and the maximum width of the host puparium from which the parasite emerged are diagrammed (Fig. 2). There is a distinct separation between size and sex in the parasite, i.e. females are larger than males. There is a separation, with little overlap, between the sex of the parasite and the host size. There is a significant correlation (corr. coeff. = 0.926, $P = 0.0001$) between parasite size and host size. These relationships indicate that host size, or available resource, is a significant factor in determining the sex and size of the parasite. We hypothesize evidence of selective oviposition by parasites based on host sex, i.e. female parasites will lay fertilized (or female) eggs into female hosts, and unfertilized (or male) eggs into male hosts (Crozier 1971, Slobodchikoff and Daly 1971, Charnov 1982).

Behavior.—*Hostfinding: Cirsium* thistle capitula that are infested do not shed achenes and remain closed and overwinter on or near the parent plant. The parasitized tephritid puparia inside these heads are insulated by the dried achenes and pappus against freezing winter temperatures. These overwintering heads, from which adults of *Pt. coloradensis* emerge in spring, are scattered among the current season's thistle plants, thereby facilitating host finding by newly emerged parasites.

Males and females were observed to fly directly to and land on the capitula of thistles where they apparently searched for food, mates, and oviposition sites. Usually, neither sex was observed on other parts of the thistles, but occasionally males were observed to land on the upper surfaces of leaves. Adults also were observed resting on the leaves of nearby plants other than thistles, but were not observed feeding, mating or ovipositing on these plants. The peak activity period for *Pt. coloradensis* was from 1000 to 1500 h. They did not remain on the thistles overnight, but were observed to fly to them each morning.

*Feeding:* On three occasions individual males and females were observed feeding on the exudate from *Paracantha gentilis* oviposition wounds.

*Oviposition:* Females search the surface of a head by antennating in an apparently random manner. In selecting an oviposition site, the female places her mouthparts on the surface, moves away, then returns and touches her mouthparts again to the same site. The number of these return visits varied from two to five. Then, positioning herself head-up on the capitulum over the site just selected, she places the apex of her metasoma on the outer surface of the bract, planting the ovipositor tip so that she can unhinge the ovipositor by stepping backwards. She continues stepping backwards until the ovipositor is perpendicular to the long axis of her body and to the outer surface of the capitulum. This allows her to balance upon the ovipositor and to pull herself downward with her legs. Drilling begins with a slight twist of the metasoma in a lateral plane and a side-to-side rocking of the body. By continuing to pull downward she pushes the ovipositor though the bracts and finally into the softer tissues of the capitulum.

Once the hole is drilled and the female has the ovipositor inserted completely into the head, she pushes with her legs in a slight up-and-down motion, presumably searching for a host larva. If none is found, she then uses her legs to push up and away from the capitulum surface to remove the ovipositor. Once removed, it is secured by stepping forward. Females were first observed to oviposit in thistle capitula in late March. They select young capitula that are fully exposed, or at least free from surrounding leaves. Apparently, *Pt. coloradensis* females do not distinguish capitula infested by *Pa. gentilis,* because early in the season they drill into uninfested capitula. This indicates that they failed to associate the oviposition wounds of *Pa. gentilis* in capitula at which the parasite adults fed with the presence of host larvae. The time spent on a capitulum by a female parasite varied from 1 min to 2.5 h. Females were observed to drill from one to six holes during observation periods that lasted a maximum of 2.5 h. The average time spent in drilling holes was 8 ± 2 ($\bar{x}$ ± SE) (range, 2–22, n = 13) min; the average time between drillings was 8 ± 2 (range, 1–15, n = 7) min. Dissections showed that if no host was located inside a capitulum, or only host eggs were present, no parasite egg was deposited. Capitula dissected after oviposition showed that drill holes occurred in rows along the vertical axis of the capitulum, from about one-third the distance between the apex of the capitulum to the peduncle. On three separate occasions females were observed drilling into the undersides of capitula near the peduncle. Five capitula collected 3 weeks after the first observation of parasite oviposition contained on average of 36 ± 5 (range, 20–49) drill holes.

Courtship.—*Laboratory:* Two each, newly emerged (<48 h old) virgin males and females were caged as couples (one male and one female) in separate screened plastic vials for ca. 30 min observation, after which they were separated. Courtship behavior began an average of 15 ± 4 (range. 5 to 30) min after caging (n = 9). Males approached fe-

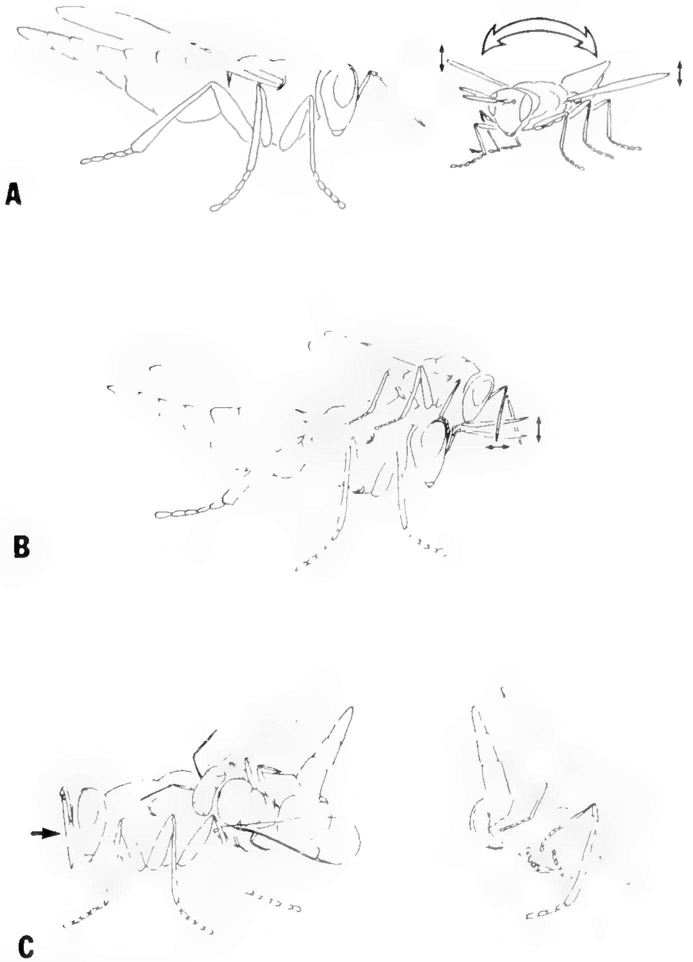

Fig. 3. (A) Male initiating courtship: dual-directional arrows indicate wing fanning and lateral weaving. (B) Antennation posture: dual-directional arrows indicate antennal movement. (C) Position of male and female *in copula* viewed from both sides. Arrow shows depressed antennae in female. Male drawn with right pair of wings removed.

males either laterally or head-on and stopped when they were 1 cm or less apart, but not touching. With his antennae extended, the male began to sway his body from side to side and fan his wings (Fig. 3A). Swaying consisted of a lateral rocking motion, while moving his body over his legs from one side to the other.

Wing fanning as a form of auditory courtship communication has been described for two other pteromalids, *Pteromalus puparium* L. and *Nasonia vitripennis* (Walker) (Miller and Tsao 1974). Experimentation has shown that males vibrate their wings at a specific frequency and pulse which is then followed by the male mounting the female. Wing fanning by *Pt. coloradensis* males also preceded their mounting of the females and beginning antennation.

Antennation occurred while the male stood on the female's dorsum with his foretarsi on the vertex of her head, his middle tarsi in front of her tegulae, and his hind tarsi grasping her axillae (Fig. 3B). The female drummed the upper surface of her funicle segments 1–3 against the closed mandibles of the male. This is in contrast to the courtship behavior described for other Pteromalidae, e.g. *Nasonia* and *Eupteromalus* (cf. Barass 1960, van den Assem 1974), where males moved their open mandibles over the upper surface of the female's funicle segments. While the female of *Pt. coloradensis* drummed her antennae on the mouthparts of the male, he intermittently stroked the lateral aspects of her antennae with his funicular segments (Fig. 3B), as is common in the Pteromalinae (van den Assem 1974). Single antennation episodes lasted an average of 3 ± 0.4 s (range, 1–5 s, n = 12). When the female was receptive, only one such episode occurred before copulation and was of short duration, i.e. ca. 2 s. If the female was unreceptive, yet still confined with the male in the vial, antennation occurred up to seven times during a 30-min period, including five times in a 10-min period, each episode terminating with the male dismounting. The intervals between male approaches varied from 1 to 30 min.

Mating.—*Laboratory:* If the female was receptive after antennation, she lowered her flagella and held them tightly against her head, a motion that has been reported to be the receptivity signal to the male (Barass 1960, van den Assem 1974), and simultaneously, raised the apical four segments of her metasoma to expose the gonopore. The male immediately moved backwards and down her left side, bent his metasoma down and under her metasoma, and placed the apex on the gonopore (Fig. 3C). This copulatory position is unusual for Pteromalinae males, which usually tend to copulate from a position behind and underneath the metasoma of the female (van den Assem 1974). The female terminated the mating by relaxing her metasoma and "shaking-off" the male. Two matings lasted ca. 30 s each. No post-copulatory behavior was observed. The male did not try to remount the female, but both actively moved inside the vial for the duration of the observation time.

*Field:* One courtship and copulation sequence was observed on the apex of a *C. californicum* terminal capitulum. The male approached the female and began swaying and wing fanning for ca. 2 s. He then mounted her for antennation as described above for ca. 3 s. Copulation followed and lasted about 1 min. Males were observed to approach, mount, antennate, and dismount any female they contacted. On separate occasions, three different males mounted and antennated a single female as she was ovipositing.

## DISCUSSION

Zwölfer (1988) discussed biogeography of thistles and suggested that they crossed into North America from the Palearctic prior to the late Miocene via the Bering Strait. Few of the associated Palearctic insect taxa followed their *Cirsium* host plants, and few insect taxa of true Nearctic origin use them for host plants. The genus *Paracantha,* however, is an exception (Goeden and Ricker 1986b, 1987a, b, Zwölfer 1988), being originally Nearctic. *Pteromalus coloradensis* may have followed its host onto *Cirsium,* having been pre-adapted, with an elongate ovipositor, to parasitizing *Pa. gentilis* in other capitula. Such an adaptation may also have resulted in the unique copulatory position of the male having to move to the side of the metasoma of the female.

The thistle-insect complexes that have been studied in the Palearctic (Zwölfer 1985, 1988) have phytophagous arthropod guilds that are in turn attacked by guilds of parasites. In southern California, there is a paucity of phytophagous species on thistles compared to the fauna of Europe (Zwölfer 1965, Goeden and Ricker 1986a, b, 1987a, b), and parasite species attacking them also are few. No other species of *Pteromalus* in North America is known to attack tephritid hosts (Krombein et al. 1978).

Information on host relationships for *Pteromalus* in North America may not give as clear an indication of generic relationships as that of European species. *Pteromalus coloradensis* was placed in the genus *Habrocytus* until *Pteromalus* and *Habrocytus* were synonymized by Boucek and Graham (1978). In Graham's (1969) discussion of the Pteromalidae of North-West Europe, 67 *Habrocytus* species were included, of which 35 (52%) had unknown biologies. Of the 32 species whose biologies were known, 14 (43%) were parasites of Tephritidae exclusively, and the other 18 species parasitized various phytophagous Lepidoptera and Coleoptera. The Tephritidae hosts listed in Graham (1969) are non-frugivorous species infesting capitula of various Asteraceae, mainly belonging to genera in the tribe Cardueae (thistles and knapweeds), e.g. *Centaurea, Cirsium* and *Carduus.* Two of the Lepidoptera and Coleoptera hosts listed were also associated with Cardueae. Of the nine *Pteromalus* species included, none were listed as parasites of Diptera. When Boucek and Graham (1978) transferred *Habrocytus* to *Pteromalus,* they invalidated the generic significance of such host relationships. Data on the biologies of a host and parasite are never complete, and often not useful in taxonomy; however, when biological information is available, such as that listed by Graham (1969), it could help to clarify taxonomic questions.

### Description of the Male

Unknown until this study, the male of *Pt. coloradensis* is described here. Body iridescent blue-green, head and thorax coarsely reticulate and tinged with gold, metasoma smooth and tinged with copper. Antenna mostly fuscous; scape, pedicel smooth and testaceous; flagellum fuscous. Coxae concolorous with thorax; trochanters testaceous; femora concolorous with coxae except apices testaceous; tibiae completely testaceous; tarsi testaceous proximally, fuscous distally. Tegulae testaceous. Wings hyaline, venation testaceous.

Head (Fig. 4A).—Head as broad as mesoscutum, coarsely reticulate, eyes separated dorsally by 1.5× their length; malar space nearly ½× eye height; clypeus striate, anterior margin cleft medially. Antenna inserted ⅓ above lower ocular line, scape length ca. ¾ eye length, nearly reaching lower edge of median ocellus; combined length of pedicel and flagellum 1.1× head width; pedicel width 1.5× length, about ½ length of first funicular segment; funicle segments quadrate, stouter than pedicel; clavus length not quite twice width, slightly longer than combined length of preceding two funicular

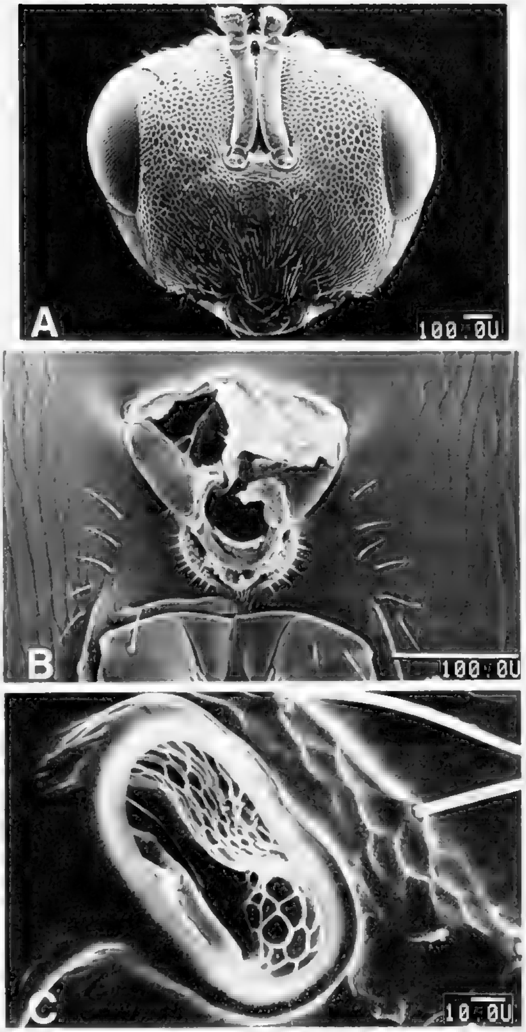

Fig. 4. (A) Anterior view of the male head. (B) Posterior view of the male head. (C) Thoracic spiracle of the male.

segments; sensilla numerous, usually in one row circumscribing funicle segment. Posterior aspect of head with many longitudinal furrows; setae sparse, a row of up to six setae on either side of occipital foramen extending from the ventral edge of the posterior tentorial bridge to the dorsal edge of the maxillary insertion, occipital foramen triangular, as wide as maxilla at insertion (Fig. 4B).

Pronotal collar sharply margined anteriorad. Propodeum width 1.8× scutellar width; 3× length; plica distinctly bordered by fine reticulation; panels shiny with longitudinal coarse wrinkles; costula distinct as a lateral band of reticulation between apical foveae; median carina absent; nucha with small wrinkles and a band of coarse reticulation at base. Spiracles elongate-oval set at ca. 45° angle to midline, inner walls with distinct reticulation (Fig. 4C).

Forewing with costal cell bare; speculum open below, extending ½ way below marginal vein; stigmal vein with one row of setae, and 1.1× longer than marginal vein and slightly longer than the postmarginal vein.

Gaster elongate-oval, length 2.2× width, dorsally compressed and with a flat dorsal surface, ventral plica; narrower than thorax; basal tergum occupying ⅓ of total length.

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# *MEGASTIGMUS FLORIDANUS* (HYMENOPTERA: TORYMIDAE), NEWLY DISCOVERED IN *ILEX* SEED (AQUIFOLIACEAE)

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*Abstract.*—*Megastigmus floridanus* Milliron was discovered to be phytophagous in seeds of *Ilex opaca* and one of its hybrids with *Ilex cassine.* This is the first report of a *Megastigmus* associated with Aquifoliaceae. A brief review of phytophagous wasps associated with *Ilex* seed is given, and adults and larvae of the two New World seed feeders (*Megastigmus floridanus, Torymus rugglesi*) are illustrated. Originally described from a single, unreared specimen from Florida, *M. floridanus* was rediscovered there, where it was reared from *Ilex* × *attenuata.* It is newly reported from Maryland from an unknown cultivar of *Ilex opaca.* Here it was univoltine, overwintering as mature larvae in mature fruit. Adults emerged in May and June.

*Key Words:* *Megastigmus floridanus, Torymus rugglesi, Ilex opaca, Ilex* × *attenuata, Ilex* 'Foster #2'

In June of 1982, Dr. Douglass Miller (USDA, ARS, Systematic Entomology Laboratory) discovered in Beltsville, Maryland a cultivar of *Ilex opaca* Aiton that was engulfed in adult female wasps of the chalcidoid genus *Megastigmus* Dalman. These wasps were emerging from mature red fruit that remained on the tree from the previous season. Species of *Megastigmus* are known to be seed-feeders, mainly on conifers and rosaceous plants, but have never been reported from *Ilex* (Lessmann 1962), nor any Aquifoliaceae.

I identified the wasp as *Megastigmus floridanus* Milliron by comparison with the single female holotype specimen collected in Florida in 1949. Nothing was known of its host or biology at the time of description, and no additional specimens have been found until this study. In 1987 I spent two weeks in Florida looking for *Megastigmus floridanus* under the auspices of The Holly Society of America. In this paper information is presented on the rediscovery of *M. floridanus* in Florida and its discovery in Maryland. Preliminary data is presented on its biology as a phytophagous feeder in the seeds of cultivars of *Ilex opaca* and natural hybrids of *I. opaca* with *I. cassine* Linnaeus. A synopsis of holly seed-feeding wasps is given as well as methods to distinguish *M. floridanus* from *Torymus rugglesi* Milliron, the only other New World holly seed feeding wasp. The latter species is also reported for the first time from a commercial cultivar of *Ilex.*

## PHYTOPHAGOUS WASPS IN *ILEX* SEED

At a world level, wasp species known to be phytophagous in *Ilex* seed are confined to the family Torymidae of the Chalcidoidea. This is the family to which *Megastig-*

*mus* belongs. Although most torymid wasps are parasitic on other insects, there are several genera with phytophagous species.

*Bootania* Dalla Torre.—This Australasian genus is closely related to *Megastigmus* and has two species in Japan which feed in *Ilex* seed. *Bootania japonica* (Ashmead) occurs in seeds of *Ilex serrata* Thunberg and *I. purpurea* Hasskarl (reported as *shinensis* Sims, Kamijo 1962); *Bootania hirsutum* (Kamijo) occurs in the seeds of *Ilex integra* Thunberg (Kamijo 1962, 1981). Records for *japonica* and *hirstum* prior to 1988 are under the generic name *Macrodasyceras* Kamijo which was recently synonymized under *Bootania* by Boucek (1988).

*Torymus* Dalman.—*Torymus rugglesi* (Figs. 2, 4) has been reared from the seeds of *Ilex opaca* in Delaware, Maryland, and Virginia (Milliron 1949). This species was omitted from "Field Guide to Insect Pests of Holly" by McComb (1986). During the period of 16 August to 30 September 1988, I discovered *T. rugglesi* emerging in large numbers from seeds of *Ilex* 'Foster #2' in Silver Spring, Maryland. This is the first record of the species from a cultivated *Ilex*. These specimens are in the collection of the U. S. National Museum of Natural History.

*Megastigmus.*—Only *Megastigmus floridanus* Milliron (Figs. 1, 3) is known from *Ilex*. Taxonomically *M. floridanus* may be distinguished from *T. rugglesi*, the only other phytophagous wasp with which it might be confused, by several characteristics. *Megastigmus floridanus* (Fig. 1) is entirely yellow, has an ovipositor that is about half the body length, and has the stigmal vein of the wing enlarged. *Torymus rugglesi* (Fig. 2) is metallic green dorsally and yellow on the remainder of the body, has an ovipositor that is slightly longer than the body, and has the stigmal vein barely indicated. The mature larvae of both species may be identified most easily based on setae. *Megastigmus floridanus* (Fig. 3) has setae confined to the first three body segments (excluding the head), whereas *T. rugglesi* (Fig. 4) has setae over most of the body. Setae in both species are white or clear and can be overlooked.

## MATERIALS AND METHODS

Field.—Over a five year period (1983–1988), observations were made at the USDA Beltsville Agricultural Research Center–West, Beltsville, Maryland, during the months of April through July. Initially two trees of *Ilex opaca* (unknown cultivar, det. T. R. Dudley) were found to be infested, but other trees within a one mile vicinity were swept and examined visually on a yearly basis for the presence of adult wasps. Because adults were abundant and fruit was readily available for dissection, I made no rearings from fresh fruit at Beltsville.

The search for Florida populations of *M. floridanus* centered upon Osceola County because the only known specimen of the wasp (the holotype) was collected there on 7 August 1929. Because the wasp I found in Maryland was on holly, I searched for habitats that could support holly species in general and *I. opaca* in particular. No specific locality was given within Osceola County, so I surveyed 23 localities over a nine day period from 1 to 9 August 1987. All hollies encountered were sampled with a sweep net for the presence of free-living, adult wasps. Both red (mature) and green (immature) fruit were collected when available and stored in paper bags that were placed in plastic bags to prevent excessive dehydration. Emergence was checked daily and all wasps were collected and killed in alcohol. Collections were also made about 100 miles north in the Ocala National Forest, Florida (Marion and Lake Counties) where nine sites were sampled over a three day period. Voucher herbarium specimens were taken from each tree from which a fruit collection was made and were determined to species by Dr. T. R. Dudley, U.S. National Arboretum, Washington, D.C. These specimens are now in the herbarium at the Arboretum. Reared wasp specimens were

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Figs. 1, 2. Adult females (scale = 0.5 mm). 1, *Megastigmus floridanus*. 2, *Torymus rugglesi*, ovipositor extended upward in drawing, but normally horizontal or down-curved.

determined by me and are in the U.S. National Museum, Washington, D.C.

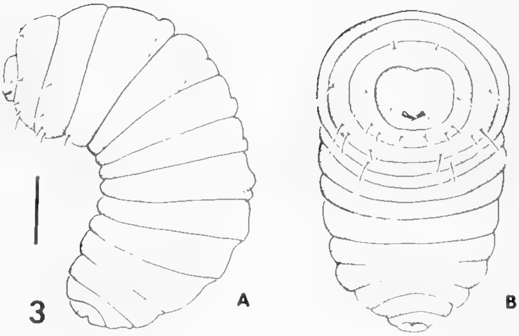
Laboratory.—Fruit for dissection was collected at Beltsville, Maryland from a single tree of *Ilex opaca* (one of the two mentioned above). This tree was part of a foundation planting and had been in place a number of years based upon the height of the tree (ca. 12 ft.). Because the presence of wasp larvae could not be determined by the external appearance of fruit, and because wasp larvae were difficult to find at the beginning of the study in 1983, fruit was first examined with x-ray equipment. After several years, as populations increased, larvae could be found in almost every fruit and dissections were made at random. Dissections were made the day after collection and larvae were killed in boiling water and stored in alcohol for future study. On one occasion, withered fruit from previous years' crops was taken from under the tree to determine if live wasps might be present in them.

## RESULTS OF FIELD SURVEY

Florida.—During the Florida field survey I swept the following holly species: *Ilex ambigua* (Michaux) Torrey, *Ilex* × *attenuata* Ashe (*Ilex cassine* × *Ilex opaca*), *Ilex buswellii* Small, *Ilex cassine,* and *Ilex glabra* Gray. No specimens of *Ilex opaca* were found. Only one free-living, adult female of *M. floridanus* was collected, and this was on *Ilex* × *attenuata.*

Fruit collections were made as follows (mature/immature): *I. ambigua* 0/1200, *I.* × *attenuata* 612/3970, *I. bushwelli* 0/100, *I. cassine* 0/16,500. Of these only *I. attenuata* produced wasp adults: 3 from mature (red) fruit and 116 from immature (green) fruit. These wasps emerged from fruit collected in Osceola County at Three Lakes Wildlife Management Area (25 mi. S. St. Cloud) and Prairie Lakes (29 mi. S. St. Cloud). Wasp emergence occurred from 7 to 26 August 1988.

*Ilex* × *attenuata* and *Ilex cassine* were the only hollies of those listed above that exhibited all stages of floral development on the same tree at the same time. That is, every stage from bud and flower to immature green fruit and mature red fruit was available as a resource at one time.



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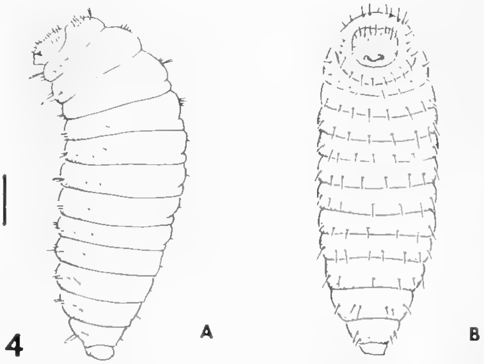

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Figs. 3, 4. Larvae of *Ilex* seed feeding Torymidae (A, side view, B, ventral view; scale = 0.5 mm). 3, *Megastigmus floridanus,* overwintering larva. 4, *Torymus rugglesi,* mature larva.

Maryland.—During the period of study, adult, free-living *Megastigmus floridanus* were collected only in the months of May and June. Adults were seen exiting from mature, red fruit still attached to the tree. During the first four years, wasps were collected only on two trees which occurred within 100 feet of each other. Although other nearby female trees were swept (from 100 yards to a mile away), no wasps were found. In 1987, adult wasps were found for the first time on four trees about 100 yards to the east. Five trees 100 yards to the west had no wasps. The tree first found to be infested with *M. floridanus* in 1982 still supported a large population of wasps in 1988.

The trees at Beltsville bloomed only in May and June. At that time, the previous season's mature red fruit remained on the tree, but there was no green fruit. After June there were no buds or flowers present and the developing fruit matured synchronously, reddening by early fall.

## RESULTS OF LABORATORY DISSECTIONS

Larvae of *M. floridanus* were found to be solitary endophytes within an *Ilex* seed. Each *Ilex opaca* fruit produced four seeds. Among 28 infested fruit the most common number of larvae per fruit was 2 (65%), but 1 (14%), 3 (14%), and 4 (7%) larvae were also found. In randomly selected fruit sampled during July, August, and October from a heavily infested tree, 80 to 100 percent (avg. 93%) of the fruit (n = 30) was infested. On a per seed basis (n = 120), 38 to 63 percent (avg. 50%) were infested, 25 to 40 percent (avg. 34%) were distorted (indicating possible ovipositor probing and perhaps egg laying), and 12 to 23 percent (avg. 16%) appeared to be sound. There was no observable difference in appearance between infested and non-infested seed, and there appeared to be no obvious external affect on the growth of the holly fruit. A small, clean, circular emergence hole in the mature red fruit was the only evidence that *Megastigmus floridanus* had been present.

In 1987, I dissected 40 fruits (160 seeds) on 11 June and the same number again on 9 July and found no evidence of eggs or larvae. Larvae were first detected on 20 July and averaged 0.6 mm in length (range 0.4 to 0.9 mm, n=14). As the overall seed infestation rate was 38 percent at this time, I probably overlooked the eggs and larvae on 11 June and 9 July. By 26 August the larvae averaged 2.4 mm in length (range 1.8 to 2.7 mm, n=17) and by 1 October they averaged 2.3 mm (range 1.8 to 2.9 mm, n=21). Random dissections of fruit in early January yielded larvae which averaged 2.2 mm in length (range 2.1 to 2.5 mm, n=13).

A single, incidental collection was made of old, blackened fruit from beneath a tree on 15 May. Forty seeds were dissected and contained three live adult females. This fruit could have fallen prematurely from the current year's crop or could have been on the ground for several years.

## DISCUSSION

Milliron (1949) outlined a general life history for *Megastigmus* in which the female adult emerged in spring and immediately oviposited into immature host seeds; one larva developed per seed, attained full growth by late summer, and remained dormant over winter; pupation occurred in spring and adults emerged with the onset of new seed initiation. I believe that *Megastigmus floridanus* follows this developmental phenology at least in the Maryland population. Adult females were present in May and June, and small larvae were first detected in late July. Larval development was completed at least by late August after which time larval length remained approximately the same through January when dissections were no longer made. I believe that I overlooked egg and early larval growth in June and early July and found only mature larvae after the August dissections. Because mature larvae were present in January I assume that this is the overwintering phase.

*Ilex opaca* in Beltsville, Maryland had a definite seasonal phenology, with one crop of buds developing synchronically, then flowers, and then fruit. *Megastigmus floridanus* appeared to track this phenology and produced one generation per year. In Florida populations of *Ilex* × *attenuata,* all stages of floral and fruit development occurred simultaneously in August. Thus there was less synchronized fruit development than on Maryland trees and more overlap of available resources. It is possible that *M. floridanus* is multivoltine in Florida, but this was not determined.

In Maryland the discovery of adult females in fallen fruit of unknown age indicated the possibility of a small portion of the population diapausing for one or more years. Diapause is known to occur in *Megastigmus,* and Milliron (1949) cited examples of several species which have retarded emergences of up to two years. This is thought to be a method of ensuring a continuing wasp population in case there should be a year of poor or bad seed production. It would be interesting to determine what percent of a year's wasp population remains in diapause and how long such dormants might survive in fallen fruit on the ground. (I have observed phytophagous wasps of the genus *Eurytoma* emerging from seeds of *Rhamnus crocea* Nuttall over a four year period in the laboratory.)

It seemed surprising, at first, that *Megastigmus floridanus* was found in seeds of both *Ilex* × *attenuata* in Florida and *I. opaca* in Maryland. *Ilex* × *attenuata,* however, is a naturally occurring hybrid of *I. opaca* and *I. cassine* (T. R. Dudley, personal communication) so that the host trees are presumably closely related. What is more surprising, however, is that none of the seeds of pure *I. cassine* yielded adult wasps in spite of the large number of collected fruits (16,500). It may be that *I. opaca* and its hybrids are the only hosts suitable for *M. floridanus* development.

The known distribution of *Ilex opaca* is Massachusetts south to Florida, west to Pennsylvania and Texas (Eisenbeiss and Dudley 1973). *Megastigmus floridanus* might be expected to have the same distribution as its host tree, but additional surveying within this potential range will be necessary to determine this.

It is odd that only recently has an apparently common and widespread seed-feeding wasp been discovered on a common and widespread plant such as American holly. In Great Britain, records of the cultivation of introduced American holly extend back as far as 1744, and over 1,000 worldwide selections have been given cultivar names in the last 40 years alone (Eisenbeiss and Dudley 1973). It would be interesting to discover the natural geographic and host range of *Megastigmus floridanus* and to determine what impact, if any, this seed-feeding wasp might have on its host trees.

## ACKNOWLEDGMENTS

I thank Douglass R. Miller, USDA, ARS, Systematic Entomology Laboratory, Beltsville, MD, for finding and collecting *Megastigmus floridanus.* For a grant in support of my fieldwork in Florida and for the publication of this paper I thank the Research and Development Committee of The Holly Society of America, Inc., Barton M. Bauers, Sr., Chairman. Additionally, I thank Charles W. McComb, Insect Population Monitoring, Bena, Virginia, for suggesting that the Holly Society might be interested in my work. For help in several aspects of my Florida field work I thank Jim Smith (retired Osceola County Agent) and Eleanor C. Foerste, Osceola County Extension Service, St. Cloud, Florida. I am grateful to T. R. Dudley, U. S. National Arboretum, Washington, D.C., for the identification of *Ilex* specimens. I also thank Robert J. Amox and the Nicolet XRD Corporation, Fremont, California for use of their x-ray instrumentation to determine the presence of wasp larvae. Finally, for reviewing this paper and offering numerous useful comments, I thank Steve Heydon, Department of Entomology, Smithsonian Institution, Washington, D.C., Manya Stoetzel and Paul Marsh, Systematic Entomology Laboratory, Washington, D.C., and Charles McComb.

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# *APTILOTUS MARTINI,* A NEW SPECIES OF THE *APTILOTUS BECKERI* GROUP (DIPTERA: SPHAEROCERIDAE) FROM CAVES IN THE CANARY ISLANDS

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*Abstract.*—***Aptilotus martini*** n.sp., a brachypterous sphaerocerid with strongly reduced eyes, is described from caves on La Palma, Canary Islands. The taxonomic status of the *A. beckeri* group within the genus *Aptilotus* is briefly discussed.

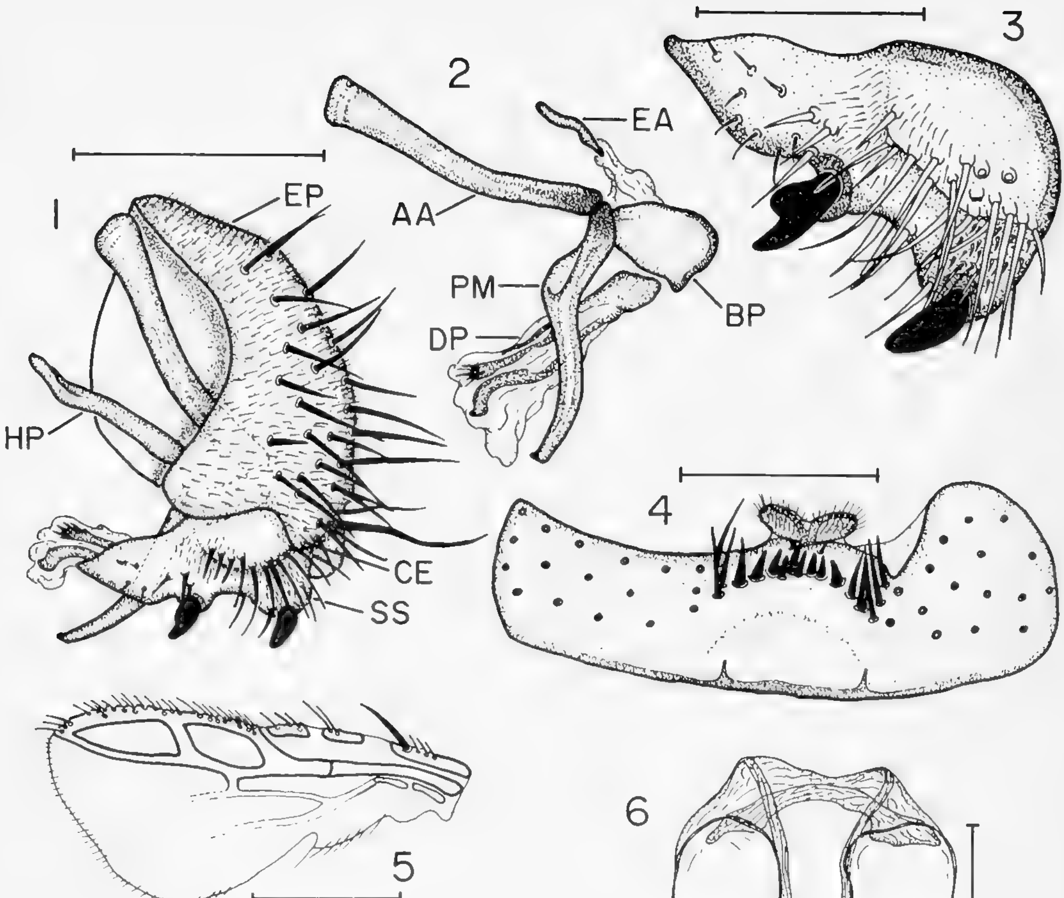
*Key Words:* Sphaeroceridae, *Aptilotus, Aptilotus martini,* taxonomy

The sphaerocerid genus *Aptilotus* Mik comprises 18 species of apterous, brachypterous, and macropterous flies, widely distributed in the Holarctic region. Six species from the Canary Islands constitute the *Aptilotus beckeri* species group (see Papp and Roháček 1981, Roháček and Papp 1983—as *Paralimosina beckeri* group). This paper provides a description of a new cave-inhabiting species of the *Aptilotus beckeri* group and summarizes the taxonomic history of the group.

### *Aptilotus martini* Wheeler and Marshall, NEW SPECIES
(FIGS. 1–9)

Description.—Body length 2.1–3.3 mm. Color dark brown, pruinose; trochanters, distal ends of tibia, and tarsomeres light brown. Interfrontal bristles in three pairs, middle pair much longer and cruciate, anterior pair shortest. Face carinate. Arista as long as thorax, with long pubescence. Eyes with indistinct margins, facets flattened, pruinose. Eye height 1.0–1.2 times genal height. Katepisternum with posterodorsal bristle strong. Two pairs of postsutural dorsocentral bristles, posterior pair longer. Presutural acrostichal setulae in ten rows. Scutellum 1.5 times wider than long, apical scutellar bristles 1.5–2 times scutellar length. Mid tibia with one long and one short anterodorsal and one posterodorsal bristle in basal third, one anterodorsal, one dorsal, and one posterodorsal bristle in distal third, one apicoventral bristle. Wing reduced, extending only to posterior margin of second abdominal tergite, wing membrane light brown. Costa ending at junction with R4+5. R4+5 straight, with R2+3 diverging at close to 90° angle. M, CuA1, and r-m present, dm-cu absent. Halter without knob, reduced to small yellow stub.

Male abdomen.—Preabdomen heavily sclerotized; densely setose except sternite 1 and anterior half of syntergite 1+2. Sternite 5 (Fig. 4) with bifid, strongly deflexed posteromedial tab. Tab lightly sclerotized with darker, roughly X-shaped region. Single transverse row of 8–10 stout spines anterior to tab, with group of 3–5 longer bristles at each end of row. Lateral regions of sternite with scattered long setae. Synsternite 6+7 simple, dextral lobe narrow, extending over posteromedial tab of sternite 5. Sternite 8 free, not fused with synsternite or epandrium. Epandrium uniformly setose, bristles longer along posterior margin (Fig. 1).



Figs. 1–9. *Aptilotus martini* new species. 1, Male genitalia (left lateral view); CE, cercus; EP, epandrium; HP, hypandrium; SS, surstylus; scale bar = 0.2 mm. 2, Aedeagal complex (left lateral view); AA, aedaegal apodeme; BP, basiphallus; DP, distiphallus; EA, ejaculatory apodeme; PM, paramere; same scale as Fig. 1. 3, Surstylus (left lateral view); scale bar = 0.1 mm. 4, Male fifth sternite (ventral view); scale bar = 0.2 mm. 5, Wing (dorsal view); scale bar = 0.2 mm. 6, Female spectacles-shaped sclerite; scale bar = 0.1 mm. 7, Female terminalia (dorsal view); CE, cercus; EPT, epiproct; T8, tergite 8; scale bar = 0.3 mm. 8, Female terminalia (ventral view); HPT, hypoproct; S8, sternite 8; same scale as Fig. 7. 9, Spermathecae.

Cercus simple, fused with epandrium, with *ca* 5 bristles, basal bristle longer than any epandrial bristle. Sternite 10 (interparameral sclerite) small but well sclerotized, arms narrow, medial part visible as a narrow dark strip between cerci. Surstylus with a setose posterolateral outer part and a long, anteriorly dark-pointed inner part bearing two large, flattened spur-like setae; anterior spur-like seta with a broad basal lobe and tapered apex (Fig. 3). Basiphallus simple, carinate. Distiphallus with a narrow collar-like base, expanding to a broad, membranous, laterally spinulose part then tapering to a distal part with a large, Y-shaped dorsal sclerite, lateral lobes bearing long flat spinules, and distal ventral part covered with small spinules. Paramere simple, slightly sinuate, truncate (Fig. 2).

Female abdomen.—Sternite 1 well-developed, bare except posterior margin; syntergite 1+2 similar in size to tergite 3, bare on anterior half; tergites and sternites 2–5 densely setose. Tergites and sternites 6 and 7 short, with only posterior bristles. Tergite and sternite 8 paler than preceding sclerites; tergite 8 tripartite, median part bare; lateral parts setulose and setose except along bare anterior margin. Sternite 8 setulose and setose on posterior half only, posteromedial margin with a row of 4 tuberculate bristles. Hypoproct setose and setulose along posterior margin only (Fig. 8). Epiproct broad, setulose except along anterior margin (Fig. 7). Cerci short, blunt, with short, stout apical and preapical dorsal bristles. Internal vaginal sclerotization (Spectacles-shaped sclerite) hyaline, with large, narrow rings (Fig. 6). Spermathecae dark, spherical, with distinct darker outpocketings; sclerotized parts of ducts short (Fig. 9).

Types.—Holotype (♂): CANARY ISLANDS. La Palma: Cueva El Diablo, 24.viii.1986, J. L. Martin. Paratypes: CANARY ISLANDS. La Palma: Cueva El Diablo, 24.viii.1986, J. L. Martin (5 ♂,14 ♀); Cueva del Rincon, 22.viii.1986, J. L. Martin (22 ♂,12 ♀); Cueva Arrebolas, 28.viii.1986, J. L. Martin (1 ♂,1 ♀); Cueva Todoque, 18.viii.1986, J. L. Martin (5 ♂,1 ♀); Cueva Franceses, 2.ix.1986, J. L. Martin (2 ♀).

Holotype deposited in the Biosystematics Research Centre, Ottawa, Canada. Paratypes deposited in the Biosystematics Research Centre, the University of Guelph collection, the British Museum (Natural History), the Museo Insular de Ciencias Naturales de Tenerife, and the Departamento de Zoologia de la Universidad de La Laguna (Tenerife, Canary Is.).

Etymology.—This species is named for Jose L. Martin, who collected the type series.

Comments.—*Aptilotus martini* is easily distinguished from all other species in the *beckeri* group by its flattened eyes, with indistinct margins. Other distinguishing characters include the shape and degree of sclerotization of the posteromedial tab of the male fifth sternite, and the shape of the male surstyli and parameres.

## Discussion

Papp and Roháček (1981) described four brachypterous species of Canary Islands sphaerocerids closely related to the macropterous species *Limosina beckeri* Duda. These four species, along with *L. beckeri*, were tentatively assigned by the authors to the genus *Paralimosina* Papp as *P. anaptera, P. beckeri, P. franzi, P. gomerensis,* and *P. pilifemorata.* Roháček (1983), recognizing that the *P. beckeri* group is morphologically distinct from other *Paralimosina* species, erected the subgenus *Paralimosina (Canarisina)* for the above five species. Almost simultaneously, Marshall (1983) noted that the *P. beckeri* group shared a number of synapomorphies with the apterous European species *Aptilotus paradoxus* Mik, and transferred the five members of the *beckeri* group to the genus *Aptilotus.*

An additional species of the *P. beckeri* group, *P. avolans,* was described by Roháček and Papp (1983), who suggested that *P. avolans* is most closely related to *beckeri.* Subsequently, these authors transferred *P. avolans* to *Aptilotus* and considered the subgenus *Canarisina* a junior synonym of *Aptilotus* (Roháček and Papp 1988). For the present, pending a complete revision of *Aptilotus,* we prefer to treat the *beckeri* group as a species group, without subgeneric status.

## ACKNOWLEDGMENTS

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# OBSERVATIONS ON *MEGANOLA SPODIA* FRANCLEMONT (LEPIDOPTERA: NOCTUIDAE) WITH A DESCRIPTION OF THE MATURE LARVA

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*Abstract.*—In 1985, Franclemont gave the name *Meganola spodia* to a species whose genitalia he had illustrated in 1960 but had left unnamed. The only mention of the larva of this species was in the 1960 paper in which a brief description of coloration was given along with the implication that Dyar's (1899) description of the *M. phylla* (= *minuscula*) larva was actually of *M. spodia. Meganola* larvae collected in West Virginia were reared to adults which are clearly *M. spodia.* The larvae are distinctly different from those previously described. Herein, I describe the last instar larva, cocoon construction and field observations for adults and larvae of *M. spodia.*

*Key Words:* Noctuidae (Nolinae), *Meganola spodia,* oak defoliation, larval description, West Virginia

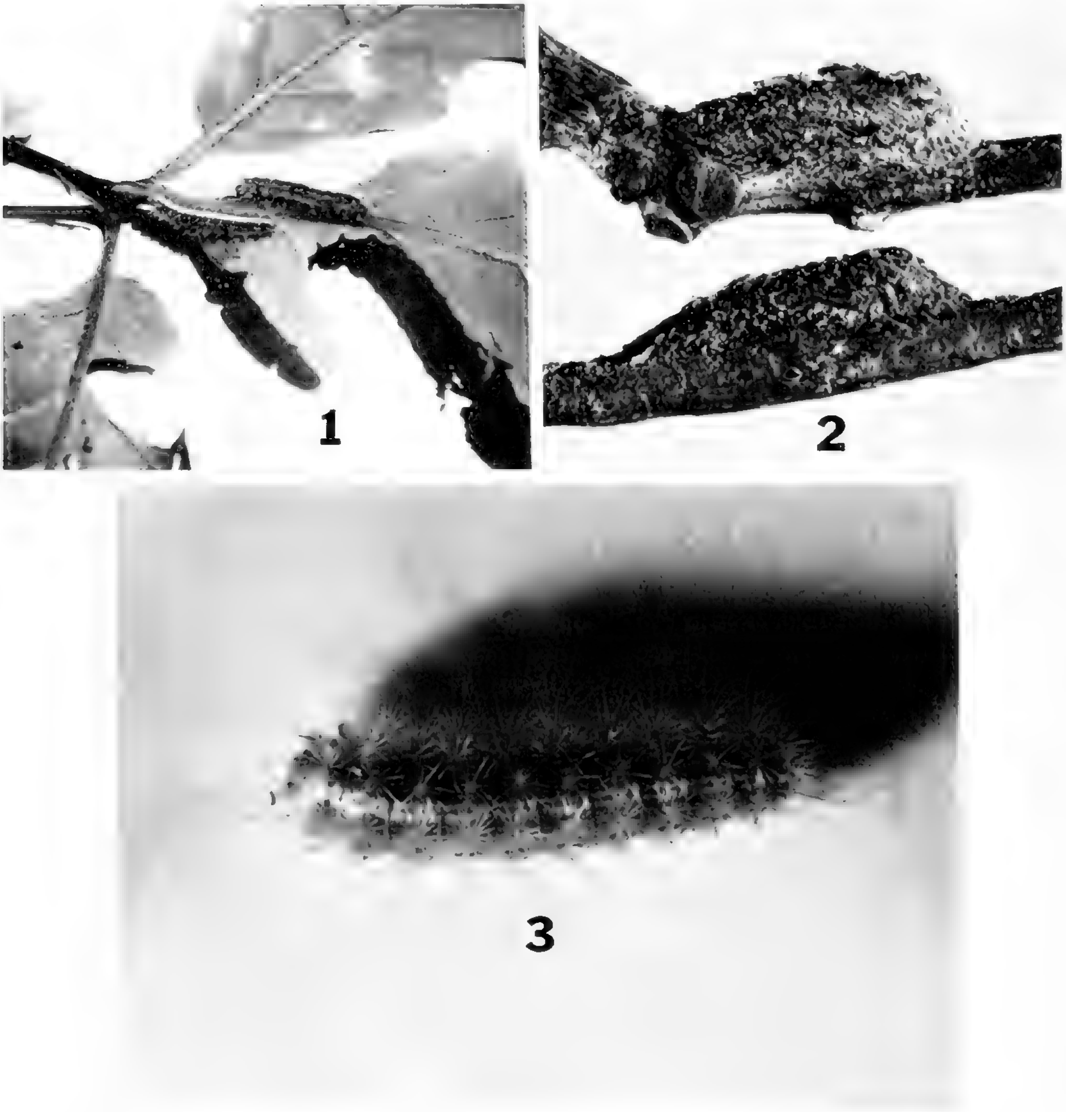
In 1983 during a study of an outbreak of spring defoliating geometrids, I collected partially mature larvae of an unknown Nolinae (Noctuidae) on oak in two eastern counties of West Virginia. Genitalia of adults reared from these larvae matched those illustrated for Franclemont's (1960) unnamed *Meganola.* Subsequently, this species was named *Meganola spodia* Franclemont (1985).

Franclemont (1960) included the following description of the larva of *M. spodia:* "dorsum pale cream color, mottled; with a dark brown subdorsal stripe, joined by transverse bands on A4 and 8; venter pale; hair pale, that on iii very long; head whitish, mottled with brown on the lobes, jaws black." Apparently, Franclemont believed Dyar's (1899) larval description of *M. phylla* Dyar (= *minuscula* Zell.) to be a description of *M. spodia.* Larvae which I reared in this study were a rich green in color; dorsal stripes were yellow and red; no transverse bands were present and longest body setae were dark brown. I do not consider Dyar's previous description of *M. phylla (miniscula)* to be that of *M. spodia.*

This paper includes field observations of larvae, a description of the last instar larva, cocoon construction and blacklight trap records for adults in West Virginia. Voucher specimens are in the West Virginia University Arthropod Collection, Morgantown.

## Biological Observations

*Meganola spodia* larvae were collected at Cacapon State Park, Morgan Co., WV on chestnut oak (*Quercus prinus* L.) on 3 May 1983 soon after leaf expansion had begun. The larvae appeared to be about half mature and were yellowish to pale green with a yel-



Figs. 1–3. *Meganola spodia.* 1, larvae and damage on oak in field (1.3×). 2, cocoons (4.1×). 3, dorsal view of last instar larva (4.6×).

low mid-dorsal stripe. I collected additional larvae on the same host species at this location on 17 May. One larva was taken from this site 24 May on black oak (*Q. velutina* Lam.). Larvae were collected from post oak (*Q. stellata* Wang.) 13, 18, and 24 May on Elkhorn Mountain near Dorcas (Grant County) WV. A total of 20 larvae were collected.

Dyar (1892) described *Meganola* (as *Nola*) *minuscula* larvae as hiding "by day in dry curled leaves that adhere to the twigs or in some other place of concealment on the branch." The larvae I observed during this study (Fig. 1) fed diurnally and unconcealed which resulted in noticeable marginal and hole feeding damage on host foliage.

Field collected larvae were maintained in the laboratory on the host species on which they were collected. All larvae produced cocoons by 29 May and adults emerged between 29 May and 18 June.

It appears as though *M. spodia* produces one generation per year and overwinters as half mature larvae.

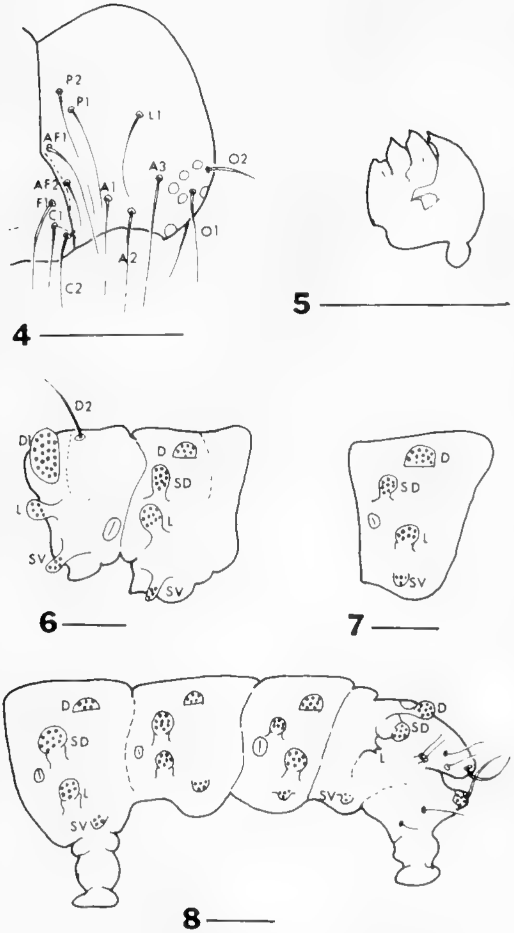
*M. spodia* adults have been recorded from New Jersey, New York, Virginia, North Carolina and Kentucky with collection dates ranging from 18 June to 16 July (Franclemont 1985). West Virginia records of adults at blacklight traps are as follows: Boone Co. (Danville) 15 June 1979, R. Swope; Fayette Co. (Babcock State Park) 11 July 1979, L. Butler; Grant Co. (Dorcas-Elkhorn) 7 July 1980, L. Butler; Lincoln Co. (Big Ugly Public Hunting Area) 28 June 1979, L. Butler; McDowell Co. (Panther State Forest) 23 June 1979, L. Butler; Monongalia Co. (Triune) 14 July 1979, L. Butler; Morgan Co. (Cacapon State Park) 17 July 1979; and Wyoming Co. (Twin Falls State Park) 3 July 1980, L. Butler. Seventeen adults from blacklight traps are in the West Virginia University Arthropod Collection.

## Cocoon Construction

Stehr (1987) described Nolidae cocoons as being well formed, boat shaped with an anterior ridge forming a valve-like slit. Packard (1884) described *Nola ovilla* Grt. cocoons as boat shaped, oval, and cylindrical attached to leaves and spun with silk and bits of leaves. Additional observations on *N. ovilla* (as *Lebena ovilla*) were "the larva builds up two parallel walls and unites them at the top. Cocoon elliptical, flat at base, size 7 × 2½ mm. The anterior end is a little higher and more pointed than the posterior" (Dyar 1894). *N. triquetrana* (Fitch) (as *N. sexmaculata* Grt. and *N. trinotata* Walker) constructs the cocoon on a piece of wood from bits of bark laid together like bricks (Dyar 1890, 1891). The cocoon of *Nola minna* Butler (as *Nola hyemalis* Stretch) was described as "not strong, composed entirely of silk, and not firmly fastened to a support. It is elliptical, opaque white" (Dyar 1891). *Meganola minuscula* (Zeller) (as *N. phylla* Dyar) cocoons were described as triangular and constructed of little pieces of bark (Dyar 1899). The cocoon of *M. minuscula* (as *Nola minuscula* Zeller) was described as "elliptical, opaque, sordid white, composed of white silk, quite tough and intermingled sparsely with larval hairs. Dimensions 8 × 4 mm" (Dyar 1892).

Cocoon construction by *M. spodia* larvae is detailed. The larva lies along the twig facing what will ultimately be the front of the cocoon and lays down a thin silk mat on the twig, lies over the mat and begins plucking small bits of twig bark (thin transparent cortex flakes and darker, bark chunks), and incorporating them into the silk, working alternately on left and right sides of the twig, thus producing flanges on each side of the twig. The larva stretches forward to pluck bark from in front of the mat and curls its body into a "C" over the edge of the mat to pluck bark from the bottom of the twig below the mat. Larvae stretch farther on smaller diameter twigs to reach enough construction material.

When the sides of the mat are each about 4 mm wide; the larva backs up, plucks bark from the twig above the mat, and applies silk and bark to produce cupping of the two sides. When each side of the mat reaches about 5 mm wide, the larva completes the front of each side by adding anteriorly extending points where each side of the mat attaches to the twig and at their outermost edges to produce flaps. The left flap is extended about 1.5 mm beyond the right. Just prior to closure, the larva begins inverting its body, alternately examining each end of the cocoon and adding bark or silk to weak spots. Closure begins at the back of the cocoon at twig level as the larva pulls the two sides together, connects them with silk and continues to close the top of the cocoon from posterior to anterior. For front closure, the larva generally adds silk to the left flap, grasps the flap with the mandibles, pulls it toward the right flap and attaches it; flap



Figs. 4–8. *Meganola spodia.* 4, head capsule, frontal view. 5, left mandible, oral surface. 6, prothorax and mesothorax, lateral view. 7, abdominal segment 1, lateral view. 8, abdominal segments 6–10, lateral view. Figs. 6–8 anterior to left. Scale lines = 0.5 mm.

closure generally progresses from bottom to top.

While cocoons were generally constructed of silk and twig bark, one larva which produced a cocoon on post oak incorporated oak bud scales into the cocoon. One cocoon on a leaf petiole consisted of petiole epidermis and leaf pubescence held together with silk.

The average cocoon construction time for those which I timed was 7 h, 42 min (range 6 h, 40 min to 8 h, 50 min).

Cocoons (n = 15) averaged 12.7 mm in length (range 11.8–13.2 mm), 3.54 mm in height (range 3.2–4.0 mm) and were produced on twigs which averaged 2.5 mm in diameter (range 1.8–3.2) (Fig. 2).

## Description of Last Instar Larva

Live last instar larvae medium green; "knobs" of verrucae reddish; narrow red dorsal stripe, continuous between segments and slightly widened at middle of each segment, bordered by yellow stripes edged laterally in red (Fig. 3).

The length of five mature ethanol preserved larvae ranged from 14.0 to 17.5 mm.

*Head* (Fig. 4): Pale tan with darker yellow-tan freckles. Greatest head width 1.78 mm. Adfrons weakly defined; frontoclypeus slightly less than one-half the distance to epicranial notch. Stemmata 1–4 evenly spaced; 6 close to 4; 5 at posterolateral edge of antennal socket. All head setae long and fine. P2 and P1 closely adjacent with P2 above and closer to epicranial suture. L1 distant from and slightly below P1 and directly above A2, which is slightly below A1; A3 slightly above stemma 3, 02 near lower edge of stemma 1 and 01 slightly above stemma 4. AF1 at junction of frontal and coronal sutures and directly above F1. C1 and C2 closely adjacent and at membranous fronto-clypeal junction. Mandibles (Fig. 5) with four outer teeth; strong tooth on inner surface; two well-separated outer setae present.

*Thorax* (Fig. 6): Ventral gland absent. Most primary setae obscured by tufts of irregularly lengthened secondary setae on verrucae. T1 shield weakly developed. D1 verrucae low, lying along anterior edge of T1, expanded transversely and almost meeting at dorsal midline; all setae brown tipped. D2 setae large, prominent, closely adjacent at midline. L verruca slightly knobbed, protuberant; setae of irregular lengths, longest uniformly brown, intermediate ones all pale and shortest setae brown tipped. SV verruca very protuberant, all setae pale. T1 spiracle elliptical, yellowish brown with darker brown peritremes; T1 spiracle 2× size of those of A1–A7.

On T2, D1 verruca low, rounded; setae of irregular lengths, none very long, most brown tipped. SD and L verrucae very fleshy, protuberant, slightly knobbed; two long, brown whip like setae on SD verruca, other setae shorter and entirely brown or brown tipped; one long, brown whip like seta on L verruca, other setae in decreasing lengths all pale, all brown, and brown tipped. SV verruca small, but very protuberant; setae irregular, all pale. T3 setal arrangement similar to that of T2, but SD and L setae not large and whip like.

*Abdomen* (Figs. 7, 8): On A1-8 all D verrucae low, rounded, all SD and L large, protuberant and slightly knobbed. L setae very irregular in length, most longer setae pale. One brown whip like seta on L verruca of A8. SV verrucae small, sparsely haired, all setae pale. A8 spiracle 2× the size of spiracles on A1–A7. On A9 (Fig. 8), D and SD well developed, fleshy, protuberant, each with two prominent, brown, whip like setae. L verruca smaller with one prominent brown seta. SV greatly reduced, sparsely haired. A10 (Fig. 8) with most setae primary. Most prominent feature is anal fork formed by four long, stout intercrossing setae. Crochets all uniordinal mesoseries; A4 and A5 with 21-22 crochets, A6 with 20–21 and A10 with 22–23.

## ACKNOWLEDGMENTS

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# SYSTEMATIC NOTES ON SOME BETHYLIDAE FROM BOTSWANA: PRISTOCERINAE (HYMENOPTERA: ACULEATA)

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*Abstract.*—***Apenesia forchhammeri,*** new species, is described from both sexes from Botswana. *Apenesia punctulata* is proposed as a replacement name for *A. punctata* Kieffer, 1904, from Cameroon, preoccupied in *Apenesia* by *Epyris punctatus* Cameron, 1888. Males and the previously unknown females of *Pristocera rhodesiae* Turner, 1928, and *Prosapenesia lacteipennis* Kieffer, 1910, are described from Botswana.

*Key Words:* Hymenoptera, Bethylidae, *Apenesia, Pristocera, Prosapenesia*

Per Forchhammer, Serowe, Botswana, has operated several Malaise traps for the Smithsonian from 1986 to the present time, collecting all kinds of flying insects. The traps were placed in a vegetation type known as *Acacia nigrescens/Combretum apiculatum* tree savanna, at an altitude ca 1500 m, with an average annual rainfall ranging from 214 to 721 mm over a period of 10 years.

Forchhammer's collecting has yielded many interesting Hymenoptera, three of the more unusual of which are described below. All species of the bethylid subfamily Pristocerinae have small wingless females. Apterous female bethylids do not enter malaise traps by their own volition. The respective males are larger, fully winged forms with large multidentate mandibles that are well adapted to grasping the small female and carrying her during a mating flight. So it is, rarely of course, that one of these mating flights occasionally terminates in a trap.

The following abbreviations, mostly as used by Evans (1963), are employed in the descriptions that follow:

LH—length of head from middle of clypeal margin to midpoint of vertex;

WH—greatest width of head including eyes;

WF—width of front (i.e. least interocular distance);

HE—height of eye measured in lateral view;

EV—distance from top of eye to crest of vertex in lateral view;

WOT—width of ocellar triangle including posterior ocelli;

OOL—ocello-ocular line, least distance between posterior ocellus and inner eye margin;

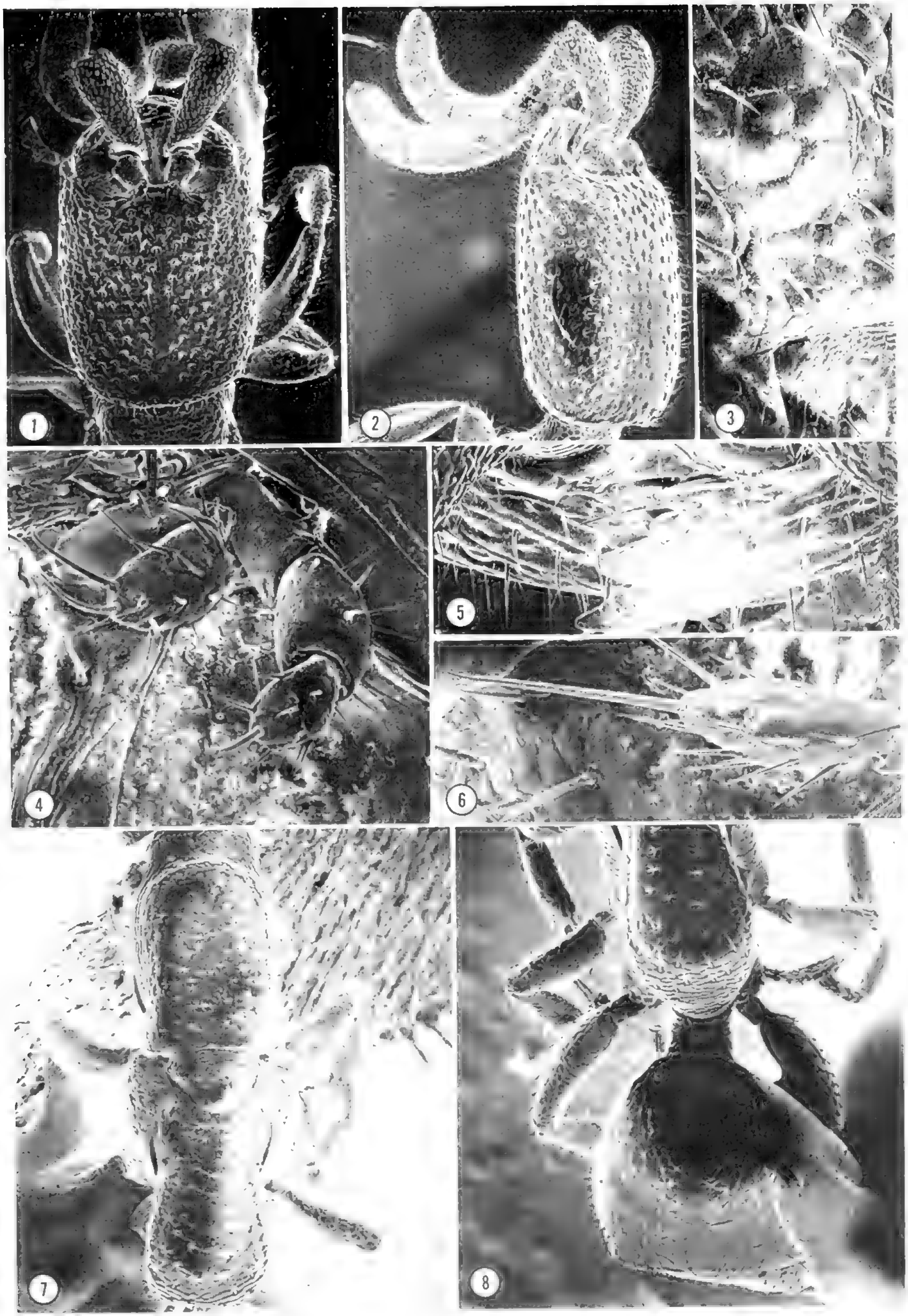
LT—length of thorax, collar excluded, from anterior margin of pronotal disk to posterior end of propodeum;

propodeal formula (females only)—anterior width: narrowest width (usually at spiracles): greatest posterior width.

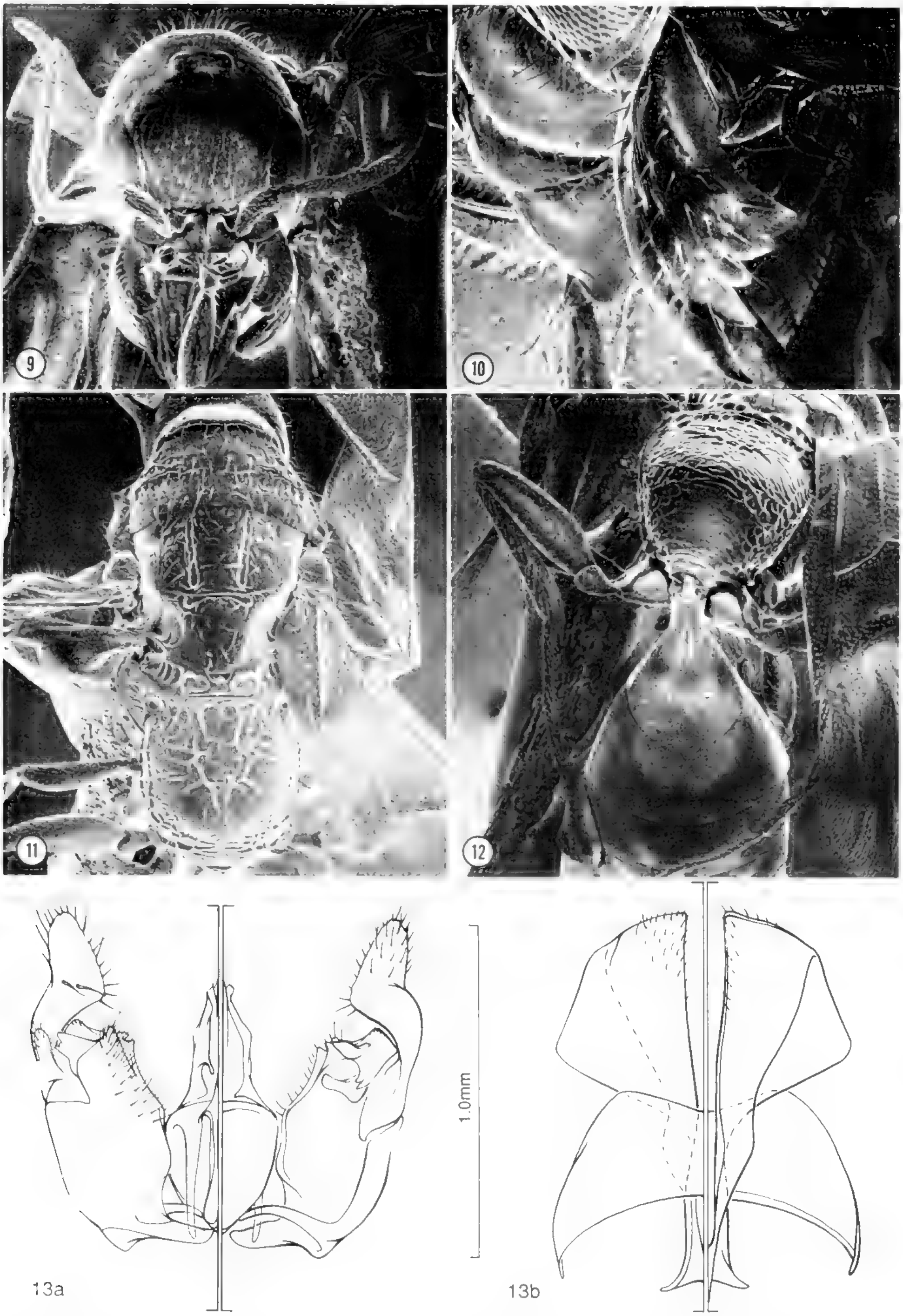
## Apenesia forchhammeri Krombein, New Species

Figs. 1–13

Kieffer (1904, 1910b) described six African species from females, none of which is similar to *forchhammeri.* Kieffer's species are either glossy and impunctate, or sparsely



Figs. 1–8. Female *Apenesia forchhammeri* Krombein, paratype. 1, Dorsum of head, 80×; 2, head, lateral, 80×; 3, eye, 535×; 4, palpi, 870×; 5, mandible, 270×; 6, terminal segment, maxillary palpus, 1140×; 7, dorsum of thorax, 80×; 8, apex of propodeum and base of abdomen, 80×.



Figs. 9–13. Male *Apenesia forchhammeri* Krombein, paratype. 9, Dorsum of head, 35×; 10, mandible, 100×; 11, dorsum of thorax, 35×; 12, propodeum and base of abdomen, 35×; 13, genitalia (a), and (b) sixth sternum and subgenital plate, dorsal aspect at left, ventral at right.

punctate and delicately alutaceous. The female of *forchhammeri* is quite densely punctate on the head, more moderately so on the thorax, and the integument of the head and thorax is strongly alutaceous.

Holotype female.—Length 2.7 mm, LH 0.6 mm, LT 0.9 mm. Head and thorax predominantly ferruginous, narrowly infuscated above coxae, apex of mandible dark, antenna light red except flagellum testaceous beneath, legs pale testaceous, abdominal petiole black, rest of abdomen light red except large infuscated blotch on first tergum and narrow infuscated band at base of second and third terga. Vestiture pale, short, erect and sparse.

Head (Figs. 1–2 of paratype) dull, strongly alutaceous, moderately densely punctate, many of punctures separated from each other by diameter of a puncture or less, LH 1.4× WH; labial palpi 2-segmented, maxillary palpi 3-segmented (Fig. 4), terminal segment of latter (Fig. 6) with apical seta 1.3× as long as segment; mandible (Fig. 5) quadridentate; clypeus narrow, apical margin truncate medially, midline strongly carinate; eye (Fig. 3) dark, ovate, small, with 5–6 facets; scape about three times as long as thick; flagellum about 2.7× as long as scape, slightly clavate toward apex.

Thoracic dorsum (Fig. 7) strongly alutaceous, more sparsely punctate than head; pronotal disk 1.3× as long as apical width; mesonotum narrower than pronotum, about 0.7× as long as wide; mesopleuron with moderately broad dorsal surface rounding abruptly to broad lateral surface; propodeum 1.75× as long as maximum width, minimum width 0.81× maximum width, propodeal formula 23:21:26; forefemur 2.6× as long as broad; mid tibia with weak spines, hind tibia with setae only.

Abdomen shining, not alutaceous; petiole (Fig. 8) composed of sternum only, stout and short, about 1.6× as wide as long.

Male.—Length 3.9–5.3 mm, forewing 2.6–3.7 mm. Body shining except propodeum rather dull from sculpturing; head black, thorax black except pronotal collar sometimes light red, abdomen black, rarely brown, last two segments light red; antenna, mandible except apex, tegula, trochanters and tarsi light red, coxae black to dark brown, latter two pairs rarely light red, femora dark to light brown, occasionally reddish beneath, tibiae brown to light red. Wings clear, stigma dark brown, veins light brown to testaceous.

Head (Fig. 9) slightly longer than broad, WH 0.83–0.95× LH; mandible (Fig. 10) robust, quinquedentate; clypeus with median apical margin broadly truncate, central carina rounded in profile, evanescent just before apical margin; WF 0.61–0.64× WH and 1.22–1.47× HE; front with relatively small, shallow, dimpled punctures separated from one another by 1.0–1.5× diameter of puncture; ocelli not enlarged, OOL 1.08–1.33× WOT, front angle about 90°; first four antennal segments in a ratio approximately 20:7:11:9, third segment 1.75–2.00× as long as wide, pubescence very short, suberect, glittering.

Thorax (Fig. 11); pronotal disk with strong anterior carina, posterior half shallowly depressed, surface sculpture variable, ranging from sparsely punctate, more densely so laterally on anterior half in smaller specimens to rather densely punctate on anterior half in largest specimens, depressed posterior half with closer, small punctures except apical rim; notauli and parapsidal lines well developed, surface of scutum variably punctate, relatively sparsely so in smaller specimens and more densely in larger; scutellum anteriorly with transverse groove, with sparse punctures concentrated along anterior groove and lateral margins of central raised disk; metanotum with a small, shallow setose pit in middle, areas laterad of this divided into a series of deeper, larger foveae separated by longitudinal carinae; propodeal disk 0.94× as long as wide, rounding apically into posterior surface (Fig. 12), posterior carina lacking, lateral carina weak, basal triangle irregularly rugose, areas laterad of triangle irregularly rugulose; posterior surface almost smooth in smallest specimens, finely, closely, arcuately carinulate in larger specimens; tarsal claws bidentate apically, without an additional basal tooth; forewing with costa extending beyond stigma about 0.6 × length of stigma.

Abdomen with short petiole (Fig. 12) composed of both tergum and sternum; subgenital plate and sixth sternum (Fig. 13b), the former deeply and narrowly divided almost to base, very broad, lateral third weakly sclerotized and doubled over to form a pocket opening anteriorly on ventral surface, sixth sternum with apical margin broadly, shallowly emarginate; genitalia (Fig. 13a) with aedeagus moderately stout, the parts closely consolidated.

Variation.—The two female paratypes are 2.5 and 2.6 mm long, and are very similar to the holotype in all details. One topotypic male, collected Dec 1987, is not included in the type series. Its measurements fall within the ratios listed above, and it agrees with other males in essential details of punctation, genitalia and subgenital plate, but the antennae and last two abdominal segments are testacous, the mandibles and tarsi are ivory, and the wing venation is white.

Type series.—Holotype: ♀, BOTSWANA, Serowe, Farmer's Brigade, malaise trap, Dec 1987, Per Forchhammer. Paratypes: 3 ♀, 18 ♂, same label data except Feb (2 ♂), Dec (♀) 1986, and Jan (♂), May (♂), Jul (♂), Oct (♀, ♂), Nov (♀, ♂), Dec (11 ♂) 1987. [All USNM.] A pair of paratypes will be deposited in the British Museum (Natural History).

Etymology.—The species is named for Per Forchhammer who has greatly enriched the national collection by his collecting in Botswana.

### *Apenesia punctulata* Krombein, New Name

*Apenesia punctata* Kieffer, 1904: 366 (♀; "Afrique occ., Mt. Camerun, 800–1200 m;" unique holotype in Genoa).—Kieffer, 1908: 25 (listed).—Kieffer, 1914: 393 (redescribed in German). Preoccupied by *Epyris punctatus* Cameron (1888: 174–175), transferred to *Apenesia* by Evans (1963: 280).

Remarks.—The coloration of *punctulata* is somewhat similar to that of *forchhammeri,* but the mandibles are bidentate in females of the former species rather than quadridentate, the pronotum is twice as long as the mesonotum rather than thrice, and the head and thorax are smooth and sparsely punctate rather than strongly alutaceous and rather densely punctate.

Etymology.—The name is the Latin diminutive of *punctata.*

### *Pristocera rhodesiae* Turner
Figs. 14–21

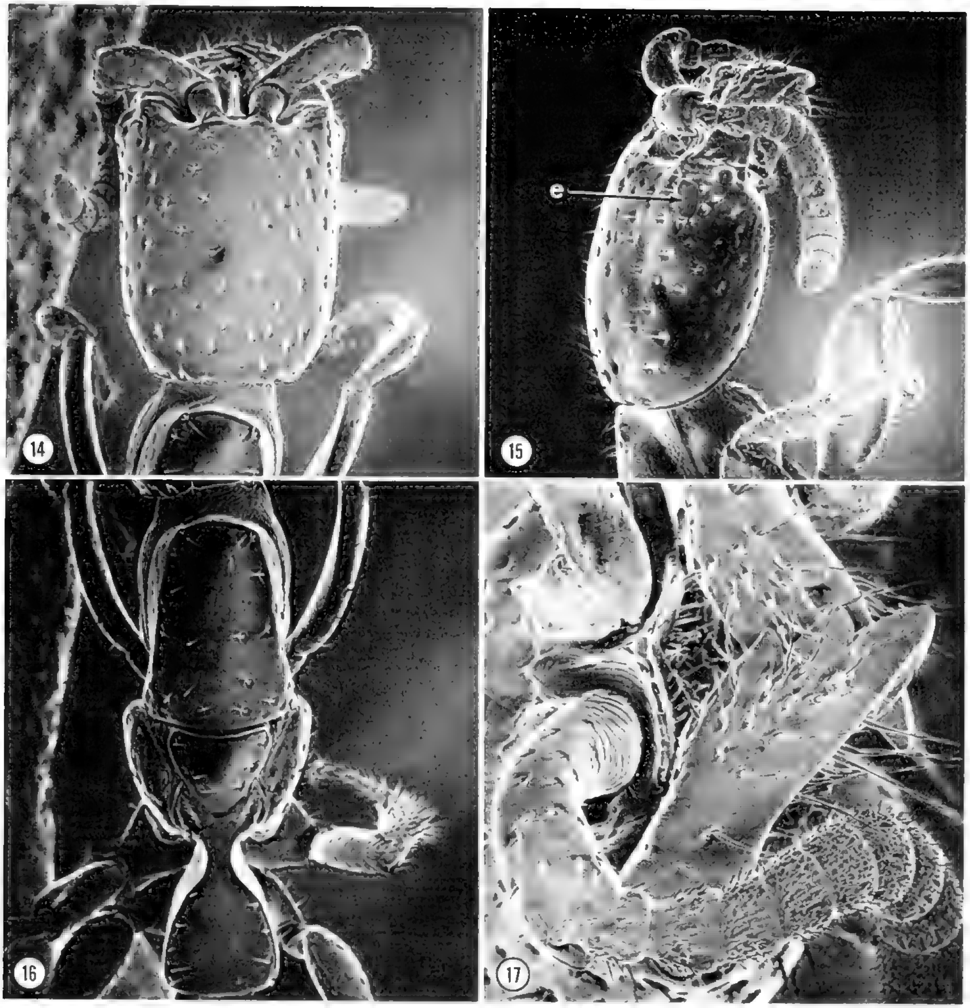
*Pristocera oriphila rhodesiae* Turner, 1928: 142 (♂; Sawmills, Southern Rhodesia; holotype now in South African Museum, Capetown).

*Pristocera rhodesiae* Turner, Benoit, 1963: 50–51, fig. 81 (holotype redescribed).

Female.—Length 4.9 mm, LH 0.85 mm, LT 1.40 mm, abdomen almost 4 × its greatest width. Body entirely light red, except mandible with teeth and outer and inner margins castaneous, eye black.

Head shining, not at all alutaceous, in dorsal (Fig. 14) and lateral (Fig. 15) views; mandible (Fig. 17) with three teeth; labial palpi 3-segmented, maxillary palpi 6-segmented; clypeus with median carina not arched, ending in a small, rounded median projection on apical margin on either side of which the margin has a weak rounded lobe with two tiny, short, rounded projections; LH 1.32 × WH, sides narrowing very slightly nearly to posterior margin where they converge more strongly to straight vertex, punctures on front small and shallow, quite sparse medially but more crowded anteriorly and laterally; eye (e, Fig. 15) small, rounded, slightly longer than high, with about eight facets, covered by a flat lens; antenna thickening gradually toward apex, segment 11 about 0.75 × as long as wide.

Thorax shining, not at all alutaceous, in

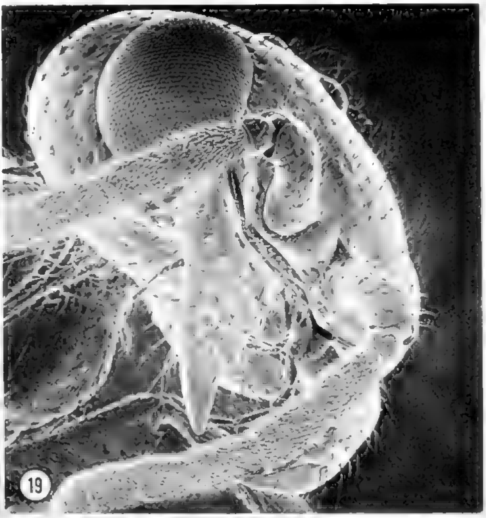


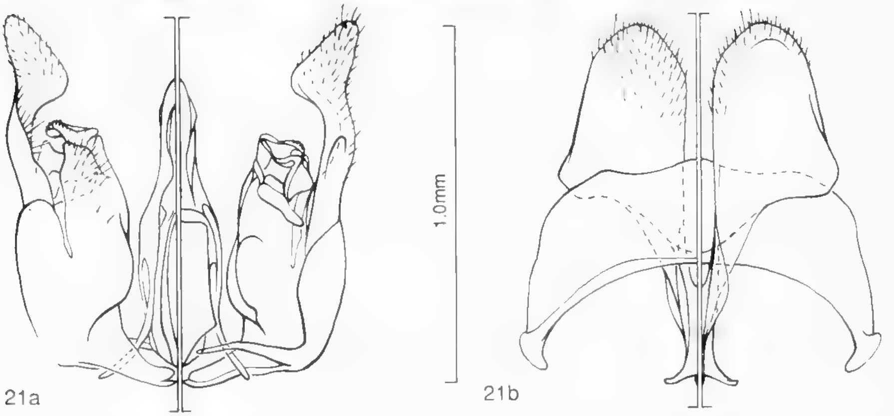
Figs. 14–17. Female *Pristocera rhodesiae* Turner. 14, Dorsum of head, 55×; 15, head, lateral (e = eye), 55×; 16, dorsum of thorax, 55×; 17, mandible, 135×.

dorsal view (Fig. 16); pronotal disk abruptly declivous to collar, 2.13× as long as wide, with very sparse, shallow, small punctures; mesonotum 0.75× as long as wide, with a few small lateral punctures; propodeum 2.44× as long as maximum width, 12.2× as long as minimum width, with a few small punctures near lateral margin beyond constriction, propodeal formula 20:5:25; forefemur flattened, 2.18× as long as wide; mid tibia with about 20 moderately stout spines.

Abdomen not petiolate, shining, with sparse, subrecumbent setae laterally and apically on the segments, terga 1–5 also with very tiny micropunctures separated from each other by several times diameter of puncture.

Male.—Length 5.1–7.5 mm, forewing 3.5–5.0 mm. Black and shining; mandible ivory to light red, except outer and inner margins and teeth dark red; tegula and basal segments of legs dark brown; seventh abdominal segment and occasionally apex of sixth, tibiae and tarsi light red. Wings subhyaline, veins light brown, stigma dark brown. Vestiture pale, glittering, suberect and moder-





Figs. 18–21. Male *Pristocera rhodesiae* Turner. 18, Dorsum of head, 30×; 19, mandible, 50×; 20, dorsum of thorax, 30×; 21, genitalia (a), and (b) sixth sternum and subgenital plate, dorsal aspect at left, ventral at right.

ate on head and thorax, decumbent and sparse on sides and apices of abdominal segments; eyes bare.

Head (Fig. 18) about as wide as long, WH 0.98–1.07× LH; mandible (Fig. 19) robust, quinquedentate; clypeus with median carina moderately arched in profile, apical margin broadly rounded; WF 1.59–1.67× HE and 0.63–0.67× WH; front with relatively small, dimpled punctures that are somewhat sparser in smaller specimens; ocelli not enlarged, OOL 0.70–1.00× WOT, front angle about 90°; first four antennal segments in a ratio ranging from 13:3:7:7 to 17:4:11:9, third segment 1.58–2.00× as long as wide.

Thoracic dorsum (Fig. 20); pronotal disk transversely carinate anteriorly, posterior third depressed, anterior part with shallow dimpled punctures that are denser toward side; scutum with larger shallow punctures that are denser on area between notauli and parapsidal lines; scutellum anteriorly with transverse groove, disk with small scattered punctures; metanotum with a small median pit anteriorly, area behind pit with fine, dense piliferous punctures, laterad of pit a larger fovea; propodeal disk about 0.8× as long as wide, rounding apically into posterior surface, medially with a weak carina reaching almost to apex, basally without a well-defined triangular area, discal surface with moderately close, irregular, transverse rugulae that are sparser in smaller specimens, lateral carina weak; posterior propodeal surface lacking median carina, with fine, close, transverse, arcuate rugulae that are sparse or evanescent in smaller specimens; tarsal claw bidentate at apex, inner tooth subparallel to outer, but much shorter and truncate apically, base of claw with small tooth; costa of forewing not extending beyond stigma.

Abdomen not petiolate; subgenital plate and sixth sternum (Fig. 21b), the former deeply and narrowly divided almost to base, lobes broadly rounded at apex, sixth sternum with a weak rounded median lobe on apical margin; genitalia (Fig. 21a) with aedeagus relatively slender, the parts closely consolidated.

Specimens examined.—♀, 10 ♂, BOTSWANA, Serowe, Farmer's Brigade, malaise trap, Per Forchhammer, Sep (♀, 5 ♂) and Nov (♂) 1986, Jan (3 ♂) and Dec 1987 (♂).

## *Prosapenesia* Kieffer, 1910

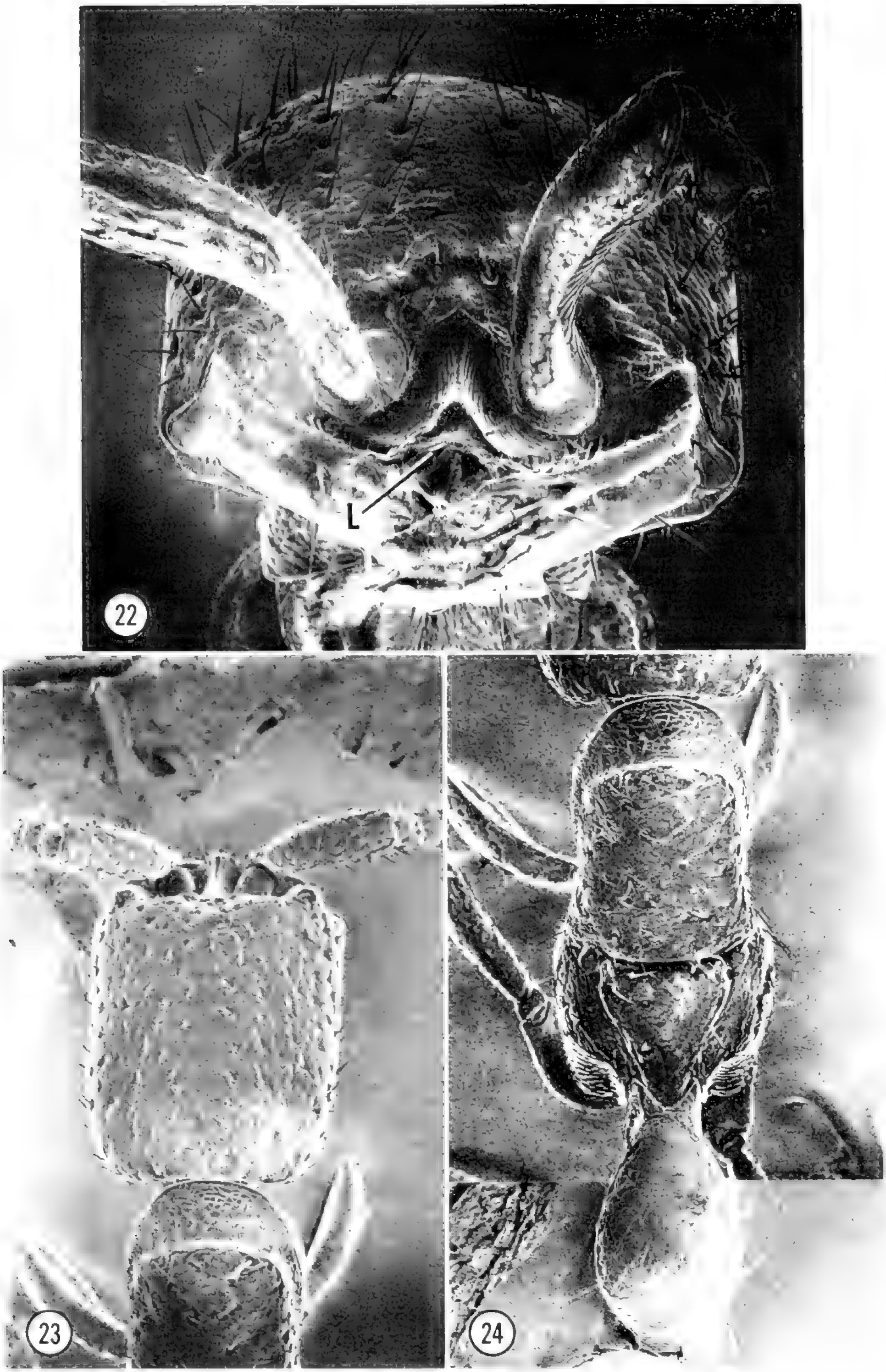
Benoit (1981) established the tribe Usakosiini for *Prosapenesia, Usakosia* Kieffer, 1914, and *Neusakosia* Benoit, 1981. The tribe was based essentially on the conformation of the seventh abdominal sternum (subgenital plate) of the male (Fig. 29b), which has the subtriangular section between the apical lateral lobes angled abruptly upward, i.e. toward the seventh tergum, as contrasted to the broadly and slightly convex surface of that sclerite in other Pristocerinae.

The fortuitous circumstance of a wingless female being carried into a Malaise trap during her mating flight provides an opportunity to describe the female of *Prosapenesia.* It shares many characters including aptery with the relatively few known pristocerine females. The eyes are entirely lacking, whereas other pristocerine females have several to many well differentiated facets. Evans noted (1964: 63) that the eyes of *Pseudisobrachium* are reduced to a single facet that is sometimes indistinct. The only other differentiating character of female *Prosapenesia* is that the median clypeal carina terminates at a narrow, truncate, thickened apical lobe (see L, Fig. 22). These two characters are too trivial to justify retention of the tribe Usakosiini.

### *Prosapenesia lacteipennis* Kieffer
Figs. 22–29

*Prosapenesia lacteipennis* Kieffer, 1910a: 43 (♂; Namibia; unique holotype in Berlin).—Kieffer, 1914: 424 (♂; redescribed).—Benoit, 1981: 835–836, figs. 1 a–c (♂; Namibia; redescribed).

Female.—Length 3.0 mm, LH 0.6 mm,



Figs. 22–24. Female *Prosapenesia lacteipennis* Kieffer. 22, Frontal aspect of head (L = clypeal lobe), 220×; 23, dorsum of head, 100×; 24, dorsum of thorax, 100×.

LT 1.2 mm. Head, mesopleuron and extreme base of abdomen very dark brown; dorsum of thorax and prosternum beneath medium brown; sides of pronotum and prosternum ferruginous; mandible except apex, clypeus, antennae, legs and abdomen light red. Vestiture pale, erect to suberect, sparse and short.

Head (Fig. 23) slightly longer than wide, WH 0.95× LH, moderately alutaceous, rather shiny, with small punctures most of which are separated from each other by 2–3 times diameter of a puncture; mandible (Fig. 22) bidentate, lower tooth more acute and longer; clypeus narrow, with median longitudinal carina that is straight in profile and terminates at a narrow, truncate, thickened apical lobe (L, Fig. 22), lower margin of truncation slightly and shallowly emarginate; eyes completely lacking; antenna 13-segmented, scape relatively slender, 4.2× as long as wide, flagellum 2.3× as long as scape, not enlarged toward apex, segments 6–10 equally wide and 0.82× as long as wide.

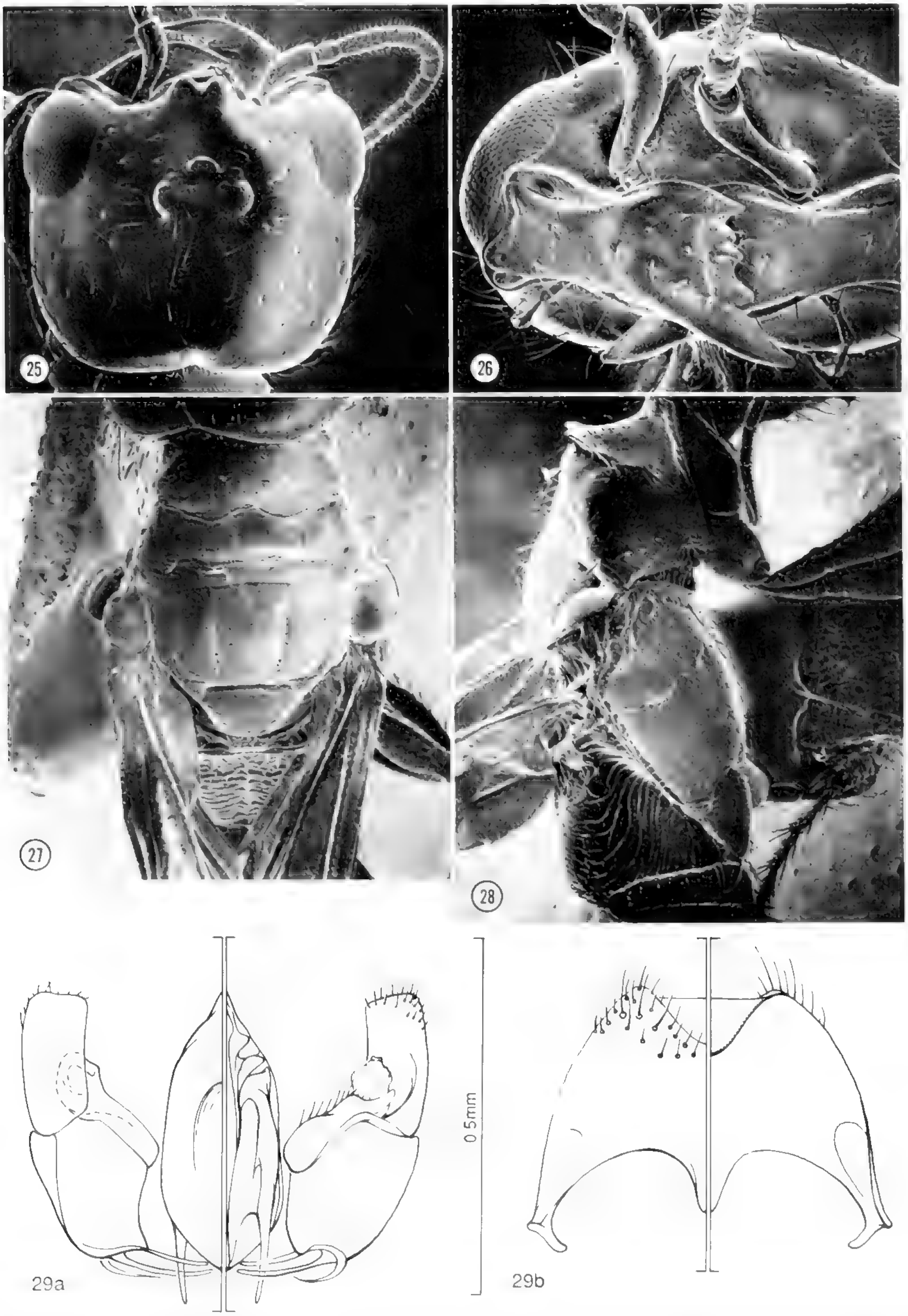
Thoracic dorsum (Fig. 24) moderately alutaceous, punctures smaller and sparser than on head; pronotal disk slightly longer than apical width, not carinate anteriorly, abruptly declivous to collar; mesonotum at base narrower than pronotum, sides converging strongly toward apex, 1.16× as long as basal width; mesopleuron with large dorsal area rounding gradually to lateral surface; propodeum more delicately alutaceous, 1.95× as long as greatest width, minimum width 0.35× maximum width, propodeal formula 9:7:20; forefemur rather slender, 3.0× as long as wide; mid tibia strongly spinose, hind tibia with setae only.

Abdomen not petiolate, shiny not alutaceous, about 2.6× as long as wide.

Male.—Length 3.7–6.5 mm, forewing 2.5–4.4 mm. Smallest specimens with integument mostly dark brown except legs lighter brown, mandible except teeth and upper and lower margins and clypeus light red; largest specimens with integument predominantly light red except apex and margins of mandible and extreme base of abdomen dark brown, scutum, metanotum, propodeum, mesosternum and lateral blotches on middle of second to seventh abdominal segments light reddish brown. Wings with a slight milky cast, stigma dark to light brown, veins light brown to testaceous. Vestiture sparse, pale, short, suberect.

Head (Fig. 25) slightly broader than long, WH 1.12–1.17× LH, posterior margin straight in smaller specimens, angularly indented in larger specimens, front in middle with bilobed process projecting above and between antennal insertions, weakly to strongly grooved along midline nearly to anterior ocellus; mandible (Fig. 26) robust, quinquedentate; clypeus narrow, apical margin broadly and shallowly arched inward on median third, surface slightly concave; WF 1.54–2.13× HE and 0.61–0.66× WH, with small, scattered punctures that are quite shallow in smaller specimens, becoming denser and deeper in larger specimens; eye slightly protuberant, EV 1.23–1.79× HE, ocular setae lacking; ocelli not enlarged, placed well forward on head, OOL 0.70–0.86× WOT, front angle of triangle about 110°; first four antennal segments in a ratio ranging from 18:6:8:9 to 36:9:19:19, third antennal segment 1.50–2.38× as long as wide; pubescence very short, dense and erect.

Thorax (Figs. 27, 28); pronotal disk abruptly declivous to collar, anteriorly with transverse, erect lamella that is narrowed toward middle, disk with scattered fine punctures, posterior half depressed; scutum with fine scattered punctures, notauli and parapsidal lines well developed; scutellum with anterior transverse groove and a few fine punctures; metanotum with small, shallow pit in middle, laterally with small foveae; propodeal dorsum rounding into posterior and lateral surfaces, median and lateral carinae weak, anteriorly usually with weak, close, longitudinal rugulae beyond which surface with close transverse rugulae; posterior surface with close arcuate rugulae; lat-



Figs. 25–29. Male *Prosapenesia lacteipennis* Kieffer. 25, Dorsum of head, 40×; 26, mandible, 85×; 27, dorsum of thorax, 40×; 28, lateral aspect of thorax, 40×; 29, genitalia (a), and subgenital plate (b), dorsal aspect at left, ventral at right.

eral surface with more separated, sinuous rugulae.

Abdomen not petiolate; seventh tergum broadly rounded at apex; subgenital plate (Fig. 29b) bilobate at apex, subtriangular section between lobes folded inward toward tergum; genitalia (Fig. 29a) with aedeagus massive, parts closely consolidated, paramere subtruncate to slightly rounded at apex, deeply concave ventrally in middle for reception of digitus and apex of cuspis.

Variation.—The forewing length is a more reliable measure of size than total body length owing to the variable degree of telescoping of the posterior abdominal segments. When the series of *lacteipennis* males is arranged in order of increasing forewing length, two significant differences are apparent. The smaller specimens, 3.3 mm or less in forewing length, include the darkest specimens, and the larger, 3.4 mm or longer, have gradually increasing amounts of light reddish brown to red integument.

The shape of the head also changes with increasing size. The posterior margin of the head is straight in the smallest specimens and the median, bilobate frontal process above and between the antennal insertions projects rather weakly. At about 3.0 mm forewing length the posterior margin of the head becomes angularly indented in the middle and the frontal process projects more strongly (Fig. 25), both of these characters becoming more accentuated with increasing size.

Specimens examined.—♀, 19 ♂, BOTSWANA, Serowe, Farmer's Brigade, malaise trap, Per Forchhammer, Sep (♂) and Nov (♀, 10 ♂) 1986, Jan (♂), Feb (2 ♂), Apr (4 ♂) and Nov (♂) 1987.

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# NORTH AMERICAN SPECIES OF *STILBOPS* (HYMENOPTERA: ICHNEUMONIDAE)

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*Abstract.*—The American species of the ichneumonid genus *Stilbops* are described: ***Stilbops latibasis,*** new species, from eastern North America and ***S. mexicana,* new species**, from Mexico. The other species of the genus occur in Eurasia, Japan, Taiwan, and the Philippines.

*Key Words*: wasps, Stilbopinae, parasite

There are two species of *Stilbops* in North America, both undescribed. This genus is the only North American representative of the subfamily Stilbopinae. A key identifying the genus and a habitus figure are in Townes, 1970. Mem. Amer. Ent. Inst. 13, pages 5, 7, and 196.

### Genus *Silbops*

*Stilbops* Foerster, 1869. Verh. Naturh. Ver. Rheinlande 25: 163. Type: *Pimpla vetula* Gravenhorst. Designated by Ashmead, 1900.

*Aphanoroptrum* Foerster, 1869. Verh. Naturh. Ver. Rheinlande 25: 168. Type: (*Lissonota rugicornis* Gravenhorst) = *abdominalis* Gravenhorst. Included by Thomson, 1877.

*Aphanoroptra* Thomson, 1877. Opuscula entomologica 8:736. Emendation.

*Aphanorrhoptrum* Dalla Torre, 1901. Catalogus hymenopterorum. . . 3: 528. Emendation.

*Eritrachynus* Schmiedeknecht, 1913. Opuscula ichneumonologica 5: 2709. Type: *Eritrachynus asper* Schmiedeknecht. Included by Schmiedeknecht, *ibidem,* p. 2724.

The genus *Stilbops* is mostly Holarctic. There are five described species in Europe (Hinz 1981), a moderate number in Russia, and ten undescribed species in other regions. Five of the undescribed species are from Japan, two from Taiwan, one from the Philippines, one from Mexico, and one from eastern North America. The latter two are described below. The Stilbopinae were first recognized as a separate subfamily by Short (1957).

Two of the European species are known to parasitize Adelidae (Lepidoptera), ovipositing into adelid eggs and emerging from cocoons of the mature larvae (Hinz 1981). Adelidae are presumed to be the hosts of the entire genus.

### KEY TO THE NORTH AMERICAN SPECIES OF *STILBOPS*

1. Underside of antenna stramineous or light brown. Tergites 6–9 black in both sexes. Tergites 2 and 3 of female mostly to entirely ferruginous, black in male. Northeastern North America. 1. *latibasis,* new species
2. Underside of antenna black. Tergites 6–9 black in male, fulvous in female. Tergites 2 and 3 black in both sexes. Mexico. 2. *mexicana,* new species

### 1. *Stilbops latibasis,* NEW SPECIES

Front wing 3.4 to 3.8 mm long. Body moderately stout. Cheek about 0.1 as long as basal width of mandible. Genal carina weak, gradually curved inward to reach oral carina about 1.1 as far above base of mandible as basal width of mandible. Clypeus with basal 0.4 convex, the apical 0.6 weakly concave. Flagellum about 0.68 as long as front wing, with 17 segments, the last few segments enlarged and the last segment quite large. Epomia rather weak, evanescent dorsad. Mesopleurum polished, with moderate sized punctures that are separated by about 0.8 their diameter. Propodeal areolation complete and strong. Second lateral area of propodeum polished, with moderate sized punctures that are separated by about 0.8 their diameter. Areolet small, obliquely triangular, sometimes absent. First tergite stout, 1.4 as long as wide in male, 1.2 as long as wide in female, its median dorsal carinae strong on basal 0.7 and dorsolateral carina sharp from base to apex. Second tergite 0.88 as long as wide in male, 0.68 as long as wide in female, with a preapical shallow transverse impression, its surface moderately mat, with moderately large punctures that are separated by about 0.5 their diameter. Ovipositor sheath about 0.58 as long as hind tibia.

Black. Mandible yellow. Palpi and under side of antenna stramineous or light brown. Tegula, front and middle coxae, and all trochanters pale yellow, the coxae and hind trochanters usually stained with fulvous dorsally. Legs beyond trochanters light or pale fulvous, the last segment of front and middle tarsi light brown. Hind tibia weakly infuscate apicad, and hind tarsus fulvous brown. Wings faintly infuscate. Male abdomen black with apical margin of tergites 2 and 3 fulvous and apical margin of tergite 4 obscurely fulvous. Female abdomen with first tergite, black with apical 0.3 to 0.4 often ferruginous. Tergites 2–4 or 2–5 ferruginous or sometimes partly infuscate, and tergites 5–8 or 5–9 blackish.

*Type:* Female, collected under trees on a moist bank at edge of a marsh, E. S. George Reserve, near Pinckney, *Mich.,* June 24, 1956, H. Townes (AEI).

*Paratypes:* Male, Crawford Notch Road, 6 miles south of Gorham, *N.H.,* May 27, 1965, G. S. Walley (CNC). Female, Ringwood (near Ithaca), *N.Y.,* June 7, 1951, C. Dasch (Dasch collection). Female, summit of King Mt., 1150 ft., Old Chelsea, *Que.,* July 12, 1965, Malaise trap (CNC). Female, Plummers Island, *Md.,* June 6, 1911, H. S. Barber (USNM).

### 2. *Stilbops mexicana,* NEW SPECIES

Front wing 3.8 to 4.3 mm long. Structure similar to that of *S. latibasis* except as follows: Propodeal carinae in female weak, evanescent. Areolet present, narrowly truncate above. First tergite 1.9 as long as wide in male, 1.3 as long as wide in female, its median dorsal carinae reaching a little past spiracle in male, reaching 0.8 the distance to spiracle in female.

Black, including under side of antenna. Mandible, palpi, tegula, and front and middle coxae and trochanters pale yellow, the middle coxae of female tinged with fulvous basad. Front and middle femora and tibiae fulvous, their tarsi brown. Hind coxa black. Hind trochanters and tibiae of male dark brown. Hind femur and tarsus of male blackish. Hind leg of female beyond coxa brownish fulvous, its tarsus brown. Tergites 6–9 of female fulvous, of male black.

*Type:* Female, kilometer 185.5 on Tuxtepec to Oxaca road, *Mexico,* 2200 m, Oct. 22, 1962, H. & M. Townes (AEI).

*Paratypes:* 2 males, same data as type (AEI).

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## NOTE

# First Record of *Thripobius semiluteus* (Hymenoptera: Eulophidae) from the New World

*Thripobius semiluteus* Boucek (Hymenoptera: Eulophidae) was described from Africa (São Tomé) and India (Mysore) (Boucek 1976, Entomophaga, 21: 401–414), and it has subsequently been recorded from Australia (New South Wales) (Boucek 1988, Australasian Chalcidoidea (Hymenoptera), CAB International, 832 pp.). As a result of ongoing studies on the biological control of greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), by one of the authors (McMurtry), *T. semiluteus* was recently collected in Brazil. This represents the first New World record for this parasite. Collection data is: BRAZIL, Minas Gerais, Lavras, 12.v.1988, J. A. McMurtry, ex. *Heliothrips* sp. on *Croton* sp. (Euphorbiaceae) and avocado (*Persea americana*: Lauraceae). This species was imported into the University of California, Riverside Quarantine facility (S&R# 88-11-1). It is being propagated in the laboratory on *H. haemorrhoidalis* on citrus and investigated as a possible biological control agent against this thrips in avocado and citrus orchards.

*T. semiluteus* is known as a parasite of Thripidae in the subfamily Panchaetothripinae. Recorded hosts are *Brachyurothrips anomalus* Bagnall, *Panchaetothrips indicus* Bagnall, and *H. haemorrhoidalis;* known host plants for this parasite are *Hibiscus, Croton,* Liquid Amber, and Valencia oranges (Boucek 1976, loc. cit; 1979, loc. cit.). Avocado represents a previously unrecorded host plant for the parasite.

Parasite identification was done by LaSalle. Specimens are in the collection at UC Riverside, and exemplars have been placed in the U.S. National Museum, Canadian National Collection, and British Museum (Natural History).

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## NOTE

# Hymenoptera Associated with a California Population of the Russian Thistle Biological Control Agent *Coleophora klimeschiella* Toll (Lepidoptera: Coleophoridae)

*Coleophora klimeschiella* Toll, whose larvae are casebearers which feed on the foliage of the weed pest Russian thistle (*Salsola australis* R. Brown), is native to Turkey and probably the Soviet Union (Khan and Baloch, 1976. Entomophaga 21: 425–428). This moth was imported into U.S. quarantine from Pakistan in 1975 and tested for host specificity. In 1977, it was released in California to control Russian thistle (Hawks and Mayfield, 1978. Environ. Entomol. 7(2): 257–261).

Several years later at a *C. klimeschiella* release site two miles northwest of Coalinga (Fresno County) California, several species of native Hymenoptera were discovered to be parasitizing the *C. klimeschiella* casebearers. The *C. klimeschiella* casebearers were gathered, the wasps reared, identified, and the rates of parasitism established.

*Coleophora klimeschiella* casebearers were collected for rearing on six dates (Table 1). By rearing *C. klimeschiella* individually in gelatin capsules and dissecting their cases after parasitoids emerged, parasitization rates and the *C. klimeshciella* stage killed were established.

Five species of Hymenoptera were reared from *C. klimeschiella*: *Macroneura* n.sp. Walker (Eupelmidae) from larvae and pupae, *Agathis gibbosa* (Say) (Braconidae) from larvae and pupae, *Spilochalcis side* (Walker) from pupae, *Spilochalcis torvina* (Cresson) from pupae (both Chalcididae), and *Catolaccus aeneoviridis* (Girault) (Pteromalidae). The stage which *C. aeneoviridis* killed was not determined, but it is recorded from many Lepidoptera and Coleoptera and as a secondary parasitoid of braconid, ichneumonid, and bethylid wasps (Burks, In Krombein et al., 1979, Catalog of Hymenoptera in America North of Mexico, Vol. I (Parasitica), Smith. Inst. Press: 806). Hence, this wasp is possibly a primary parasitoid of *C. klimeschiella* or a secondary parasitoid of *A. gibbosa*.

Four additional wasp species were reared in sleeve cages containing Russian thistle and *C. klimeschiella* casebearers: *Haltichella rhyacionia* Gahan (Chalcididae), *Epipteromalus* n.sp. Ashmead, *Norbanus perplexus* Ashmead, and *Pachyneuron* sp. Walker (all Pteromalidae). These species were possible parasitoids of *C. klimeschiella* or from undetected hosts on or in the Russian thistle. A female specimen of *H. rhyacionia* (Coalinga, 2-X-1985, H. Misthe, reared from *Coleophora klimeschiella* in *Salsola australis*, em. 31-X-1985) in the University of California Riverside collection supports the former association. These records of a known central and eastern United States species (Burks 1979, ibid.: 860) in California is a significant range extension for this species. *Norbanus perplexus* is reported from and in this case possibly parasitized *Coleophora parthenica* Meyrick, a stem burrowing Russian thistle feeder introduced from the Mediterranian region (Goeden, Ricker, and Muller, 1978. Environ. Entomol. 7(2): 294–296). This is the first rearing information for the genus *Epipteromalus*. *Solenopsis xyloni* McCook (Formicidae) was observed preying on *C. klimeschiella* casebearers. In three of five observations, two to four ants attacked a single *C. klimeschiella* casebearer.

In all, 1523 *C. klimeschiella* and 453

Table 1. Parasitism of *Coleophora klimeschiella* (CK) casebearers near Coalinga, California, 1982–1984. Acronyms for hymenopterous parasitoids are AGGI—*Agathis gibbosa* (Braconidae); CAAE—*Catolaccus aeneoviridis* (Pteromalidae); MASP—*Macroneura* n. sp. (Eupelmidae); SPSI—*Spilochalcis side* (Chalcididae); and SPTO—*Spilochalcis torvina* (Chalcididae).

| Coll. Date | No. CK Cases w/Emerg. | % CK Emerg. | % Parasitism | | | | |
|---|---|---|---|---|---|---|---|
| | | | MASP | AGGI | CAAE | SPSI | SPTO |
| V-26-82 | 587 | 79 | 20 | <1 | <1 | 0 | <1 |
| VI-10-82 | 177 | 52 | 47 | <1 | 0 | 0 | 0 |
| VI-23-82 | 374 | 90 | 7 | <1 | 0 | 1 | 1 |
| VIII-3-82 | 250 | 97 | 2 | 0 | 0 | <1 | <1 |
| VI-2-83 | 151 | 95 | <1 | 4 | 0 | 0 | 0 |
| V-8-84 | 437 | 56 | 5 | 38 | <1 | 0 | 0 |
| Total | 1976 | 77 | 13 | 9 | <1 | <1 | <1 |

parasitoids were reared to adult emergence (Table 1). No insects emerged from many cases. Parasitism (based on emergence) averaged about 22 percent but ranged from 3 to 48 percent among collection dates (Table 1). *Macroneura* n.sp. and *Agathis gibbosa* were most numerous; the other parasitoids were rarely reared.

The wasps *Macroneura* sp., *Cerambycobius* sp. (both Eupelmidae), *Hockeria* n.sp. (Chalcididae), *Catolaccus aeneoviridis* (Girault) (Pteromalidae), an unidentified ichneumonid, and a coleopterous predator *Phyllobaenus atriplexus* (Forster) (Cleridae) were reared in a field colony of *C. klimeschiella* at Indio, California (Goeden et al. 1978). The *Hockeria* specimens belong to a widely distributed, polyphagus species currently in manuscript (Halstead, in prep.). With the exception of *C. aeneoviridis* and possibly *Macroneura* sp., the parasitiods that I reared are not recorded from *C. klimeschiella*. However, some of these species are known parasitoids of other *Coleophora* species (Burks 1979, ibid; Carlson, In Krombein et al., 1979. Catalog of Hymenoptera in America North of Mexico, Vol. I, Smith. Inst. Press: 315–740). The *Macroneura* and *P. atriplexus* reared by Goeden et al. (1978) are also known enemies of cecidomyid (Diptera) gall-makers on *Atriplex* spp., a species which commonly inhabits areas with Russian thistle, and hence was thought to be the source of those insects. Additional host or plant associations for the *C. klimeschiella* parasitoids at the Coalinga site are unknown.

The adaptation of native parasitoids was possibly a reason for the poor establishment and ineffectiveness of *C. klimeschiella* as a biological control agent in southern California (Goeden et al. 1978). The same appears to be occurring at the Coalinga site.

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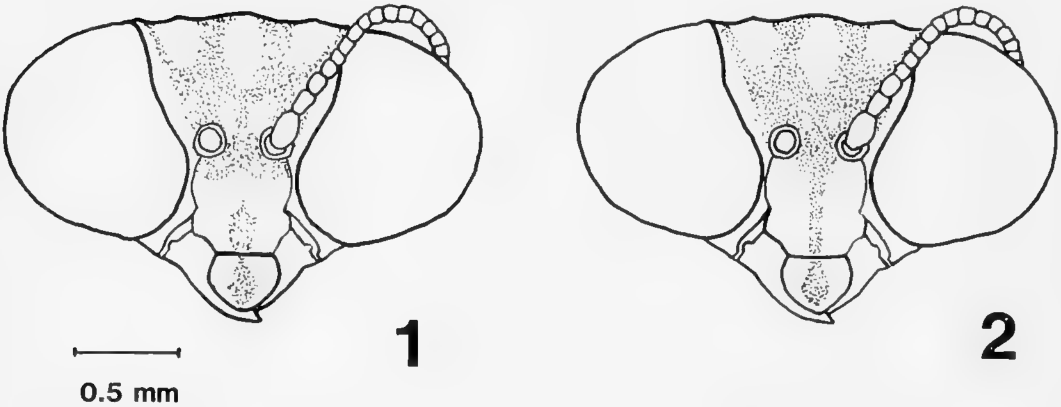
## NOTE

# Taxonomic Status of *Mantispa sayi, Mantispa fuscicornis,* and *Mantispa uhleri* (Neuroptera: Mantispidae)

The North American mantispines *Mantispa sayi* Banks (1897. Trans. Am. Entomol. Soc. 24: 21–31), *Mantispa fuscicornis* Banks (1911. Trans. Am. Entomol. Soc. 37: 335–366), and *Mantispa uhleri* Banks (1943. Psyche 50: 74–81) are currently considered sibling species (Macleod, in Hughes-Schrader, 1979. Chromosoma 75: 1–17), even though recent investigators have found them to be essentially indistinguishable both karyotypically and morphologically (Hughes-Scrader 1979), (Redborg, 1982. J. Arachnol. 10:92–93). There have been extensive biological studies on *M. uhleri* (Redborg and MacLeod. 1985. Ill. Biol. Monogr. 53, 130 pp.) and natural history observations on *M. fuscicornis* (Gilbert and Rayor. 1983. J. Kans. Entomol. Soc. 56: 578–580), (Rice, 1986. J. Kans. Entomol. Soc. 59: 121–126), although no significant biological differences were noted. All three species reportedly were reared in the laboratory, but only data on *M uhleri* was published (Redborg and MacLeod 1985). I recently examined the type specimens of these species in the Museum of Comparative Zoology (MCZ), Harvard University, as part of an ongoing revision of the New World Mantispinae. A reevaluation of the taxonomic status of these species was prompted by the examination of these types and of numerous other specimens from Arizona, Arkansas, Connecticut, Florida, Georgia, Illinois, Kansas, Maryland, Minnesota, Mississippi, Missouri, Nebraska, New Mexico, Ohio, Oklahoma, South Carolina, Texas, Utah, and Mexico.

The original description of *M. sayi* was based on one specimen from Texas and two from Lake Worth, Florida, coll. Mrs. Slosson. The only type specimen of *M. sayi* in the MCZ is a male with the following verbatim label data: "Type," "Brazos Co., Tex.," "Collection N. Banks," "Type 10767," "type *Mantispa sayi* Bks." *Mantispa fuscicornis* was described from two specimens collected in Florida, one from Kissimmee and another from Lake Worth, coll. Mrs. A. T. Slosson. Both type specimens of *M. Fuscicornis* are present in the MCZ. There is a male with the label data "Kissimmee Fla," "Collection N. Banks," "M.C.Z. Type 10769," "type *Mantispa fuscicornis* Bks," and a female with the label data "type," "L. Worth, Fla," "Collection N. Banks," "M.C.Z. Type 10769." The absence of the other two *M. sayi* syntypes and the similarity of their collection data with those of the female syntype of *M. fuscicornis* suggest that this specimen was originally one of the type specimens of *M. sayi.* While the lack of a 10767 type label of the *M. fuscicornis* female might argue against such a conclusion, the numbers currently assigned to the type specimens of both *M. sayi* and *M. fuscicornis* were most likely assigned well after the original descriptions of both species. All specimens of a given type series at the MCZ are assigned identical type numbers, but prior to 1920 Banks did not designate type numbers in his species description of mantispids. The type numbers (10767, 10769) assigned to the two species in question are very close to the type numbers (10758–10762, 10770) currently assigned to the type specimens of species described by Banks in 1913 (Trans. Am. Entomol. Soc. 39: 201–242), as well as to the type numbers (10774–10778) designated by Banks in his descriptions of mantispid species in 1920 (Bull. Mus. Comp. Zool. 64: 299–362). Therefore, the specimen from Lake Worth would not be expected to bear a *M. sayi* type number even if it were part of that type



Figs. 1, 2. *Mantispa sayi.* Color patterns on heads of male specimens collected on 20 July 1968 at Corpus Christi Lake State Park, San Patricio Co., Texas. Anterior view.

series. Because of the uncertain status of the specimen from Lake Worth, I hereby designate the syntype male of *M. sayi* from Brazos Co., Texas, as the lectotype of *M. sayi* and the missing specimens from Lake Worth, Florida, as paralectotypes. In addition, the male of *M. fuscicornis* from Kissimmee, Florida, is hereby designated the lectotype of *M. fuscicornis* and the female from Lake Worth, Florida, is designated as the paralectotype.

Banks (1911) did not include any characters to distinguish *M. fuscicornis* from *M. sayi,* and noted only that *M. fuscicornis* was similar to *M. sayi* in general structure. Redborg (1982. J. Arachnol. 10: 92–93) subsequently used facial markings to separate *M. fuscicornis* from both *M. sayi* and *M. uhleri,* stating that only *M. fuscicornis* possessed a broad, inverted Y-shaped line on the frons, with the forks of the Y looping under the antennal sockets. I have found that the face markings of *M. sayi* vary considerably (Figs. 1, 2) and that the range of variation encompasses what I assume are the facial markings attributed both to *M. fuscicornis* (Fig. 1) and to the other two species. (Fig. 2). Examinations of genitalic and other morphological characters of the type specimens and of specimens from the aforementioned locations has revealed no basis for the continued separation of these species. Therefore, I hereby consider *Mantispa fuscicornis* Banks to be a junior synonym of *Mantispa sayi* Banks (NEW SYNONYMY).

The holotype female of *M. uhleri* is located in the MCZ along with four female paratypes. In distinguishing this species from the preceding two, Banks (1943) referred to its almost entirely black abdomen and to the upward extension of the dark face mark to the vertex. I have found that the dark brown to black markings on abdominal segments of *M. sayi* females are often more extensive than those of males, causing female abdomens to look darker. Redborg and MacLeod (1985) also noted this dimorphism for *M. uhleri.* Therefore, the color differences noted by Banks could be attributed to this sexual dimorphism if Banks was comparing the female types of *M. uhleri* to the male types of *M. sayi* and *M. fuscicornis.* Also, the abdomen of the holotype of *M. uhleri* is discolored, darkened, partially adhered to the left hind wing, and missing both the third abdominal tergite and all segments posterior to the fifth. Therefore, the poor condition of the holotype may have contributed to Banks' diagnosis if the present condition of the holotype is essentially unchanged from 1943. The difference in facial markings mentioned by Banks has been discussed above. In addition, I examined first instars obtained from *M. sayi* females collected in Texas and could find no differences between these specimens and the description of *M. uhleri* first instars provided by Redborg and MacLeod (1985). Therefore, for essentially the same reasons given earlier when designating *M. fuscicornis* a junior synonym of *M. sayi*, I consider *Mantispa uhleri* Banks to be a junior synonym of *Mantispa sayi* Banks (NEW SYNONYMY).

The synonomy of both *M. fuscicornis* and *M. uhleri* with *M. sayi* results in the biological information on the two former species being combined and attributed to the latter. The clarification of the status of these names at this time facilitates future studies on the ecological characteristics of *M. sayi* and allows meaningful comparisons between life-history characteristics of this species and other mantispines.

I am grateful to the following persons for the opportunity to examine specimens under their care: Robert W. Brooks (Snow Entomological Museum, University of Kansas), Philip J. Clausen (University of Minnesota), Lewis L. Deitz (North Carolina State University), Herbert L. Dozier (Clemson University), David K. Faulkner (San Diego Natural History Museum), Oliver S. Flint, Jr. (National Museum of Natural History), Norman D. Penny (California Academy of Sciences), Marlin E. Rice (Iowa State University), Terence L. Schiefer (Mississippi Entomological Museum), Scott R. Shaw (MCZ), Cecil L. Smith (University of Georgia), Lionel A. Stange (Florida State Collection of Arthropods), and Charles A. Triplehorn (The Ohio State University). I also thank Peter H. Adler and John C. Morse (Clemson University) and one anonymous reviewer for their helpful comments on this manuscript. This study was funded in part by an Ernst Mayr Grant from the MCZ. This is Technical Contribution No. 2923 of the South Carolina Agricultural Experiment Station, Clemson University.

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## NOTE

# Black Walnut, *Juglans nigra*: A New Host Record for *Colaspis favosa* (Coleoptera: Chrysomelidae)

*Colaspis favosa* Say is a small, metallic-green, eumolpine chrysomelid that is widespread in the southeastern United States (Blake. 1977. Proc. Entomol. Soc. Wash. 79: 209). Adults of *C. favosa* have been associated with several species of woody plants including apple (*Malus* spp.), silverleaf scurfpea [*Psoralea argophylla* (Walt.) Cory.] (Douglas. 1929. J. Kansas Entomol. Soc. 2: 10), wax myrtle (*Myrica* sp.) (Kirk. 1970. South Carolina Agric. Exp. Stn. Tech. Bull. 1038, Part 2. p. 88; Chapin. 1979. Coleopts. Bull. 33: 450), azalea (*Rhododendron* sp.) (Loding. 1900. Geol. Surv. of Alabama Monogr. 11: 1), blackberry (*Rubus* spp.), live oak (*Quercus virginiana* Mill.) and pine (*Pinus* spp.) (Kirk. op. cit.). Except for Loding's (op. cit.) mention of *C. favosa* as a pest of azaleas, it is not clear whether other host records for this insect represent 1) instances in which *C. favosa* actually fed upon the plant listed or 2) incidental captures on a non-food plant (e.g. pine is a suspect record given the preponderance of angiosperm records for this apparently oligophagous insect).

During early June 1988, I collected adults of *C. favosa* from black walnut (*Juglans nigra* L.) trees growing in a small grove in Blacksburg, Montgomery County, Virginia. I observed beetles feeding on black walnut foliage both on the tree and when confined in petri dishes with fresh leaflets. Feeding was restricted to leaflet margins and damage to trees was negligible since beetles were present in low numbers. This is the first record of *C. favosa* feeding upon foliage of black walnut. Host plant and insect voucher specimens have been deposited in the herbarium and insect museum at Virginia Polytechnic Institute and State University, Blacksburg.

Reported hosts of *C. favosa* (e.g. *Myrica* sp. and *Rhododendron* sp.) were absent from the vicinity of the black walnut grove from which I collected beetles (the grove is surrounded by several kilometers of agricultural land), suggesting that the use of black walnut by this species was not just a temporary shift from a preferred primary host to an adjacent secondary host. Rather it is possible that black walnut may be a significant but overlooked host plant for *C. favosa* in the southern Appalachian Mountains, particularly since plants of the genus *Myrica* [apparently important coastal plain hosts (Chapin op. cit.)] are absent from this region (Harvill et al. 1986. Atlas of the Virginia Flora. p. 97). Interestingly, the Myricaceae and the Juglandaceae are placed into the order Juglandales by some authors (Benson. 1959. Plant Classification. p. 316) suggesting a close relationship between these two plant families.

I thank Dr. M. C. Thomas of the Florida Department of Agriculture, Florida State Collection of Arthropods, Gainesville, Florida, for identifying *Colaspis favosa.* K. Williams and an anonymous reviewer provided useful comments on the manuscript.

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# BOOK REVIEW

*The Guild Handbook of Scientific Illustration.* Edited by Elaine R. S. Hodges, with Lawrence B. Isham, Marsha E. Jessup, and G. Robert Lewis. Van Nostrand Reinhold. 1989, xv + 575 pp., 631 black-and-white and halftone images, 36 color images, 3 charts. Library of Congress Catalogue Card Number (LCCCN) 88-10599, International Standard Book Number (ISBN) 0-442-23681-6, hardbound, 8½ × 11" matcoated stock, $85.95 US.

After approximately 14 years since its inception, *The Guild Handbook of Scientific Illustration* evolved into the most encyclopedic volume on scientific illustration available. The text is in a 3-column format and is written in an easily readable style throughout, a characteristic not found in most multi-authored volumes, regardless of subject. The numerous black-and-white, halftone, and color images represent not only "fine art," but conceptualize information found in the text. The appendix includes sources for most tools and equipment mentioned in the text, available degree programs, professional organizations, and sources of business information. A bibliography arranged by chapter rounds out this comprehensive work.

*The Guild Handbook of Scientific Illustration* emphasizes the fact that scientific illustration is more than the rendering of attractive images, and that scientific illustrators must possess (1) knowledge of their subjects and of the conventions within the area of science for which they work, (2) ability to distinguish between important details and those that are anomalous, (3) command of basic rendering skills so that the most appropriate technique can be chosen for a specific subject to ensure optimal reproductive results, and (4) knowledge of current copyright laws and general business operations and practices. The volume is divided into five parts: *Basics, Rendering Techniques, Subject Matter, Beyond Basics,* and *The Business of Scientific Illustration.* Each part details one of the knowledge and skill prerequisites necessary for all scientific illustrators.

Part 1, *Basics* (Chapters 1–4), discusses the roles and responsibilities of the scientific illustrator and the scientist/client. Protocols from the initial meeting, through the detailed preliminary drawing and final rendering, to storage of originals are examined in detail. The relationship between scientific illustrator and scientist/client is described as dynamic, and vital to the scientific accuracy and aesthetics of the final product. The artist relies on the client for the subject matter and information about what must be represented, while the client relies on the skills of the artist to convey the characteristics that are diagnostic. Recommendations on tools and materials that scientific illustrators use from day-to-day are examined with insights on surfaces, media, drawing tools, mounting materials, measuring devices, and general drawing procedures. Because scientific illustration is important as a permanent record, archival considerations pertaining to the durability and permanence of surfaces and media, as well as storage equipment, are discussed in detail. These features are not treated in other references I examined (see References below). The section closes with an illustrative presentation on different types of lighting and tips on how to depict shadows, transparency, iridescence, and highlights.

Part 2, *Rendering Techniques* (Chapters 5–11), introduces the reader to various kinds of rendering techniques using line-and-ink, pencil, coquille board, carbon dust, watercolor-and-wash, gouache-and-acrylics, scratchboard, and airbrush. Each technique is presented in a step-by-step illustrative fashion and followed by a discussion of the technique. Included in this section are variations and modifications of basic rendering techniques derived from the experiences of the authors. In addition, materials, media, and tools used for each technique are presented along with the author's encouragement to experiment with a variety of mixed-media techniques, e.g. wet-with-wet, dry-with-dry, and wet-with-dry media on various surfaces, because only through experimentation are innovations made.

Part 3, *Subject Matter* (Chapters 12–22), introduces the reader to the general aspects of classification and morphology of selected taxa, and to current methods and techniques in illustrating plants, fossils, invertebrates, fishes, amphibians and reptiles, birds, mammals, wildlife illustration, anthropological artifacts, and medical subjects. Examples demonstrating the method of triangulation for rendering fish and reconstructing archaeological ruins, the use of coordinate measurements for rendering animal skulls, and the reconstruction of fossil taxa are illustrated and presented in great detail. In addition, methods for rendering plants from hebarium specimens, and the use of potsherds to estimate the physical dimensions and original painted surface patterns of ancient pottery are discussed. Optical and measuring devices, drafting aids, specimen-handling tools and props, special containers, wetting agents and preservatives, and miscellaneous materials used to handle specimens characteristic to the various subdisciplines of natural history are also discussed. As some study objects may be represented by only one specimen, the care and handling of such objects is an important consideration in scientific illustration.

The last two parts of *The Guild Handbook of Scientific Illustration* (Parts 4, 5) discuss pertinent background information for the scientific illustrator and the scientist. Except for topics in Chapters 24, 26, and 27, which are thoroughly covered by Anderson et al. (1988), other texts I examined either superficially treat or omit such information (see References below). The remainder of the review thus summarizes each chapter in parts 4 and 5.

Part 4, *Beyond Basics* (Chapters 23–27), discusses a potpourri of information from rendering charts, diagrams, and geographical maps to giving practical advice on the use and mechanics of the microscope as well as tips on copy photography and the printing process.

Chapter 23 discusses the function, use, and proper maintenance of the microscope. Because most subject areas within scientific illustration require the use of compound and stereomicroscopes, it is essential for the illustrator and scientist to understand how to make the best use of these instruments. For example, relationships between the focal point, focal length, and optical axis are discussed according to the properties of positive and negative lenses. Resolution is explained in conjunction with the numerical aperture of objectives, eyepieces, and substage condenser unit. In addition, illumination for both compound and stereoscopic microscopes is discussed.

Chapter 24 explores the use of diagrammatic illustration for the presentation of scientific results by the use of charts and diagrams. Information on various instruments, surfaces, and media are presented. Line and bar charts, scattergrams, pie graphs, stacked bar charts, tables and diagrams are defined and illustrated, each according to its most appropriate use(s). In addition to various lettering techniques, conventional drafting techniques and applications to computer-graphics methods are compared.

Chapter 25 introduces cartography to the scientific illustrator. A list of academic courses is given as an indication of educational experience needed to become a well-rounded cartographer. Similarly, instruments and materials (surfaces, media, and tools) used in cartography are listed. Cartographical rendering techniques are presented with respect to the understanding and use of projections and various kinds of map rendering techniques. Figure-ground maps, visual-hierarchy maps, areal maps, and various relief representation maps are illustrated and discussed. The importance of the kind, use, and placement of lettering, point symbol designs, and line symbol designs are emphasized.

Chapter 26 discusses the three basic elements of copy photography, i.e. alignment, composition, and exposure. The procedure of photographic copying involves illumination, preliminary alignment, determination of exposure, and finally taking the picture. Specific photographic applications related to linework, continuous tone, and color reproductions are discussed. Additional considerations and special materials used for archival purposes also are considered. Finally, evaluation of reproductions with respect to excessive or inadequate contrast, loss of sharpness and detail, uneven lighting, and discrete blemishes are examined.

Chapter 27 discusses the printing process and how line and halftone reproductions are made. These considerations are important because original illustrations not only need to be tailored to the dimensions of the journal or book they will be printed in, but also to the printing process used by the publishing company. The complementation of lettering with the original and use of labelled overlays also are discussed. The chapter ends with a comparison of spot color reproduction for line illustration and process color reproduction for tone illustration.

Part 5, *The Business of Scientific Illustration* (Chapters 28–30), discusses the legal rights and general business practices of the scientific illustrator. Topics of importance include reproduction and ownership rights to specific works, contracts, and general duties for the proper and efficient operation of a freelance business.

Chapter 28 introduces the reader to the new copyright law of 1 January 1978, and how it applies to scientific illustrators. This chapter emphasizes the importance of copyright registration necessary for particular types of work. By law, the owner of the copyright has the exclusive right to reproduce, sell and distribute the work, prepare derivative works, and perform the work publicly. All or part of the copyright privileges are negotiable items between the illustrator and the client. Finally, the copyright law is discussed as it pertains to infringements and "fair use" practices.

Chapter 29 stresses the importance of written contracts. These documents vary in complexity depending on the nature of the work to be done, and the artist-client relationship. Consequently, contracts generally possess several of the following terms of agreement: an accurate description of services, fees, deadlines and payment schedules, copyright, ownership of artwork, creditlines and signatures, alterations, additional artwork, provisions for termination of artwork, and incapacitation or death of illustrator.

Chapter 30 introduces the reader to the "real world" of freelance business. Strategies for surveying geographical areas in which contracts can be established and tips for estimating potential markets are presented. Types of portfolios and the presentation of art work to prospective clients are considered. Studio and office management duties and responsibilities are outlined according to the daily routine of storing and filing of business records and supplies, maintaining ledger books, as well as keeping track of deficits. Other aspects of freelance businesses, such as the option of incorporation, home office tax considerations, use of employees, insurance and retirement plans are discussed.

In conclusion, *The Guild Handbook of Scientific Illustration* gives the serious student of scientific illustration an introspective view of the basic knowledge, skills, and drive necessary to be successful within the field. Its holistic approach and detailed conceptual descriptions surpass the information content and instructive qualities of any other volume previously written on the subject (see References below). And in my opinion, these factors by far justify the price. I give this volume my highest recommendation as a reference for all professional scientific illustrators, students interested in scientific illustration, and all scientists who consider "fine art" as important a tool in science as their computer algorithms.

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Comparative statements in this review are based upon examination of the following current works on scientific illustration:

Anderson, J. et al., 1988. *Illustrating Science—Standards for Publication.* Council of Biological Editors, Bethesda, Maryland, x + 297 pp., 112 black-and-white and halftone images, 10 color images.

Barlowe, D. and S. Barlowe. 1982. *Illustrating Nature—How to Paint and Draw Plants and Animals.* The Viking Press, 111 pp., 176 black-and-white and halftone images, 29 color plates.

Downey, C. and J.L. Kelly. 1982. *Biological Illustration—Techniques and Illustration.* The Iowa University Press, vii + 126 pp., 74 black-and-white and halftone images.

Jastrzębski, Z.T. 1985. *Scientific Illustration—A Guide for the Beginning Artist.* Prentice-Hall Inc., iv + 319 pp., 129 black-and-white and halftone text images, 11 within appendices, 10 color plates.

Leslie, C.W. 1980. *Nature Drawing—A Tool for Learning.* Prentice Hall Press, xvii + 206 pp., 257 black-and-white and halftone images.

Wood, P. 1982. *Scientific Illustration—A Guide to Biological, Zoological, and Medical Rendering Techniques, Design, Printing and Display.* Van Nostrand Reinhold, 148 pp., 214 black-and-white and halftone images, 34 color images.

Zweifel, F.W. 1961. *A Handbook of Scientific Illustration.* The University of Chicago Press, xv + 132 pp., 66 black-and-white and halftone images.

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## BOOK REVIEW

# Alms for the Spore

*Insect-Fungus Interactions.* Edited by N. Wilding, N. M. Collins, P. M. Hammond, and J. F. Webber. 14th Symposium of the Royal Entomological Society of London in collaboration with the British Mycological Society. Academic Press, London. xvi + 344 pp. $33.00 U.S.

The associations of insects and fungi are numerous and diverse, but until recently have received little attention. There have been few efforts to either compile references to an extensive and scattered literature or to promote communications between the expansive fields of entomology and mycology. As co-editor, with mycologist Meredith Blackwell, of one such effort (*Fungus-Insect Relationships,* 1984)— that complemented an earlier volume on symbioses edited by L. R. Batra (1979)— I would disagree with this volume's jacket which reads in part "The invited papers given at this meeting provide the first summary of this fascinating field. . . ." But in the product of the symposium is found much to agree with. The book complements these earlier contributions in many useful ways.

The volume consists of ten chapters and a substantive appendix. Four chapters deal explicitly with associations between insect and fungus taxa (Coleoptera-fungi by Lawrence; Macrotermitinae-*Termitomyces* by Wood and Thomas; leaf-cutting ants-fungi by Cherrett, Powell and Stradling; and bark and ambrosia beetle-fungi by Beaver. The remaining six are focused on one or more basic or applied aspects of ecology.

Lawrence's chapter on mycophagy in the Coleoptera is a masterful contribution. The descriptive ecological catagories proposed for the modes of feeding in beetles will help in the general categorization of the habits of fungus-associated beetles, and will be found applicable to taxa outside the Coleoptera. Treatment of marginal substrates is important because many groups of beetles can only be ecologically characterized by their associations with such habitats, and not with particular fungus hosts (see, e.g. Crowson 1984). Plasmodial feeding in *Agathidium* has recently been confirmed in a second subgenus (Wheeler 1987), adding to the suspicion that such habits may be more widespread. While Lawrence suggests that it is too soon to generalize about coevolution of beetles and fungi, he does provide some fascinating correlations with structural features, notably mouthparts. Lawrence's suggestion that mycophagy or saprophagy was the ancestral habit in the Coleoptera is not unequivocal. It does agree with another leading coleopterist's ideas on the subject (Crowson 1981), and is perhaps as good an estimate as is today possible. I would only point out the following. The groundplan for Archostemata is not firmly established and if this suborder is used as an outgroup for the other three, no conclusion about habits is yet unambiguous. While rhysodids are a fascinating departure for the Adephaga into mycophagous habits, it is doubtful that these are anything but a secondary adaptation to such habits and can not be unequivocally argued as a groundplan for the adephagans. Myxophagan mouthparts may well be independently evolved for their peculiar aquatic habits, and can not yet be tied overtly to anything resembling a mycophagous life style. In the Polyphaga, within which mycophagous habits are common and widespread, insufficient knowledge of relationships exists to say with any certainty what the ancestral habits were. Further, some taxa suggested to be possible outgroups for the Coleoptera (e.g. Megaloptera) are predatory. I think that Lawrence has done the best job possible today in summarizing the breadth of associations in the order, and he has paved the way for the more phylogenetically detailed studies that are badly needed.

This chapter was only one of two excellent contributions by Lawrence. The appendix, co-authored with Peter Hammond, alone is worth the price of the volume. This is the first overview of fungus-insect associations in a concise, tractable form. It is fully as authoritative as I have come to expect from either of its authors. In my view, the only shortcoming of the appendix (and one that pervades the entire volume), is the use of a letter-and-number codon system for taxonomic references (cf. Tables I and II of appendix). I did not find any cases where the system led to mistakes in the text, but these might be difficult to detect. A similar system was used by Crowson (1981), with numerous resultant problems in the text (Wheeler 1982). Most of those errors I attribute to the publisher failing to have the manuscript thoroughly reviewed. Academic Press (the same publisher) seems to have done an outstanding job in the case of Wilding et al. My problems with such systems are simple. First, when errors are made, they are not easily spotted. Second, the reader is forced to refer to the table for most taxonomic citations including those she is already familiar with. And last, mycologists and entomologists are cushioned from exposure to the "other" nomenclature that will ultimately lead to familiarity. These shortcomings are, at least from a publisher's view, offset by the cost savings of not printing long and repetitious scientific names. I am less convinced of the benefits accrued to readers.

Hanski provides an informative characterization of the fungus as an insect habitat, and suggests that several general ecological questions can be addressed using this system. While polyphagy might be explainable in the terms suggested by Hanski (strong selection for polyphagy or low-cost of such diverse habits), historical momentum may be of importance in the ultimate answer. It may be that in many kinds of insects polyphagous ancestors beget polyphagous descendant species and that this phylogenetic (historical) component is stronger than either selection for polyphagy or for lower energy costs for any one of these taxa.

Several authors discuss mutualistic associations, including those shared by termites and fungi (Wood and Thomas in Chapter 3), leaf-cutting ants and fungi (Cherrett, Powell and Stradling, Chapter 4), bark- and ambrosia-beetles and fungi (Beaver, Chapter 5; Berryman, Chapter 6). These chapters provide excellent introductions to several mutualistic fungus-insect relationships, but some fall to a greater or lesser degree into ecological just-so stories. Perhaps the least constrained Neo-Darwinistic yarn was that about the evolution of ambrosia beetles by Beaver (p. 136):

> "It seems probable that this evolutionary process occurred in tropical rain forests, in which the high temperatures and humidity are particularly favourable for fungal growth, and where associations between beetles and fungi would frequently have occurred. Atkinson and Equihua-Martinez (1986) suggest that the utilization of fungi as a primary source of food may have arisen from competition between beetles and fungi for the same substrate. Such competition might frequently have occurred in different beetle-fungus associations, leading to the multiple evolution of the ambrosia habit."

Evolution of ambrosia habits need not have taken place first in tropical forests. Lawrence (Chapter 1) has suggested that fungus associations are taxonomically widespread, including many beetles and fungi in the temperates. An examination of similar habits in Lymexylidae, for which there exists a cladogram (Wheeler 1986), leaves the picture equivocal. The Hylecoetinae, sister-group to the other subfamilies, is today only North Temperate in distribution while the common ancestor of Melittomminae plus Lymexylinae is hypothesized to have been Pantropical. Where did such habits evolve? A model of a *Hylecoetus*-like ancestral species, living in temperate forests, evolving its mutualistic association with fungi is no less tenable than a Pantropical model. For the ambrosia beetles, no such cladogram yet exists. Any attempt to interpret the evolution of ecological strategies will be flawed outside of the context of a credible cladistic model for evolutionary history.

Several chapters address applied aspects of fungus-insect interactions, including the dissemination of tree pathogens (Webber and Gibbs, Chapter 7) in an excellent overview of modes of transmission and several case studies; the role of an *Ips* beetle and *Urocerus* woodwasp in the transmission of disease in larches (Redfern, Chapter 8); a very good introduction to mycopathogens of insects in epigeal and aerial habitats by H. C. Evans (Chapter 9); and a similarly good introduction to mycopathogens of soil insects by Keller and Zimmermann (Chapter 10).

The overall emphasis of the volume is on ecology, with comparatively less attention given to evolution. Where discussions about evolution were given, they did not reflect recent advances in analytical taxonomy. As one measure, I did not find a single citation to a paper dealing with systematic theory. No major emphasis is necessarily appropriate to this book, but many conclusions reached in it are dependent upon an accurate picture of evolutionary pattern and that picture depends on the application of credible analytical methods.

In general I would observe that the issue of the separation of pattern and process (e.g. Eldredge and Cracraft, 1980) has not yet reached studies of fungus-insect interactions. Such criticism does not apply to the chapters in Wilding et al. uniformly, but it is widespread enough to merit mention. The abundant, complex interactions of insects and fungi represent the end products of a great deal of evolution. Until these products are tied together in an historical framework we shall never make sense out of them. Some authors, Lawrence for example, have recognized this ("Clearly there is a need for further rigorous cladistic analyses of both beetles and fungi," p. 19) and are leading the way toward more robust theoretical frameworks within which to interpret this wondrous diversity.

This volume is an important contribution to the ecology and evolution of fungus-insect associations and to the application of this knowledge to systems of applied interest. It is exceptionally well written, edited, and produced and is a credit to the authors, editors, and sponsoring societies. Some of my criticisms point to better interpretive and synthetic contexts that are available for looking at comparative data. Others reflect the analytical compromises likely to be found in the face of the enormous numbers of insects and fungi that interact with one another and the small number of scientists studying them. These we may assume will be corrected in time. This volume represents an important compilation of current knowledge in this vast field. Several contributions, including the appendix, will be essential referential material for mycologists and entomologists alike, and the others uniformly suggest productive lines of additional research. Science progresses through the collective efforts of her practicioners. Those of us interested in fungus-insect relationships have just been given an important stepping stone, and fungi and their insect associates are at last beginning to receive the attention they deserve.

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# BOOK REVIEW

*Catalog of the Heteroptera, or True Bugs, of Canada and the Continental United States.* T. L. Henry and R. C. Froeschner, editors. 1988. E. J. Brill. xix, 958 p.

*Noctuidae.* R. W. Poole. 1989. E. J. Brill (Lepidopterorum Catalogus, new series, Fasc. 118 (Pt. lxii, 500 p.; Pt. 2: 501-1015 p.; Pt. 3: 1015-1314 p.).

Both obtainable in the United States and Canada from E. J. Brill (U.S.A.), Inc., P.O. Box 467, Kinderhook, New York 12106, at $58.50 for the Heteroptera catalog and $250 for the Noctuid catalog (3 vols.), plus in both cases USP shipping charges.

These two catalogs of large and economically important insect groups are very different in nature and content.

The Henry and Froeschner catalog of Heteroptera is a catalog in the traditional senses of the term. All species known to occur in its stated range, viz., 3834 species, are listed with full literature references, summary distribution, and synonymy. Each family is preceded by a general discussion and one to several habitus figures. The world classification is outlined and the place therein of the regional species is given. In short, it is virtually all that could be expected of a regional catalog and would serve well as a model for such. All that I miss in it is specification of the nature of data given in the references, whether there are figures (habitus, genitalia, etc.), sexes described, descriptions of immature stages, mention of host plants, etc.

The catalog of noctuid moths is very different from the foregoing. It is more than a checklist, inasmuch as complete reference, type data, and some other items are included, but it is otherwise narrowly minimal. The fact that it lists for the first time all species of Noctuidae of the world, approximately 38,000 through 1980, and that the group is of great economic importance, have both limited its scope and enhanced its value.

The 3 volumes consist of 2 volumes of text and one of bibliography and index. The arrangement is entirely alphabetical by genera and species. Suprageneric classification is indicated only by a subfamily name following the generic name, these being basically according to the Nye classification. It is also stated in the introduction that a new classification as well as lists of genera included under each suprageneric category is in preparation. Subspecies are cited under species as synonyms because the author "does not subscribe to the subspecies concept."

Only the original form of each species name is cited, regardless of gender of any genus with which it may presently be combined. I have inveighed against this practice in a previous review in this journal in 1984 (Vol. 86, pages 328–329), stating then that I thought the practice was confined to a small number of systematists. I still think so and now believe that the number is even less than I thought then. If a user of this catalog wishes to follow the rules of the International Code of Zoological Nomenclature in regard to gender concord, he will receive no help therefrom. In the genus *Plagiomimicus* (masculine) 37 species names are listed, only 3 of them in masculine form, 7 in neuter form because they were originally proposed in *Stibadium*, and at least 7 in feminine form.

After each species name (in semibold type) are cited the author's name and the name of the genus in which the species was originally proposed, both of these latter in the same regular Roman type without parentheses, punctuation, or in distinctive type-face. This seems to me to be carrying economy a little too far.

Synonymy is complete and references to type data, figures, larval descriptions, and food plants are cited. No locality records except that of the type are cited. References to generic transfers, except for new ones here made, are not given; for example, it is not indicated where or when the transfers of *Stibadium* species to *Plagiomimicus* were made. The author states that the many new combinations were "based on my own research but more commonly they are the combinations or synonymies in the collections of the U. S. National Museum of Natural History and British Museum of Natural History that have never been published but are based on the curation of past systematists, often of unknown identity."

George C. Steyskal, *Cooperating Scientist, Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, c/o U.S. National Museum of Natural History, Washington, D.C. 20560.*

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91(4), 1989, pp. 651–658

# SOCIETY MEETINGS

## 944th Regular Meeting—December 1, 1988

The 944th Regular Meeting of the Entomological Society of Washington was called to order by President Gene Wood in the Naturalist Center, National Museum of Natural History, at 8 p.m. on December 1, 1988. Twenty-three members and 8 guests were present. Minutes of the November meeting were read and approved with one emendation.

Membership Chairman G. B. White read the name of the following applicant for membership: Rick McMullan, Germantown, Maryland. Chairman White also reported that the Executive Committee had unanimously elected Frank W. Fisk of De Land, Florida, to Emeritus status. Dr. Fisk has been a member of our Society since 1968; he retired from Ohio State University in 1976.

Annual reports were given by the outgoing President, Membership Chairman, Corresponding Secretary, Treasurer (read by F. C. Thompson), Custodian, and Program Chairman. President Wood warmly thanked all Society officers for setting a standard of job performance that is the envy of other entomological organizations.

President Wood and D. M. Anderson again presented the slate of nominees for officers in 1989, which this time included Jeffrey R. Aldrich as candidate for President-Elect. Dr. Wood then called for additional nominations from the floor, of which there were none. A motion was made and seconded that the slate be accepted as presented. The motion was approved by acclamation.

President Wood read a letter from Manya B. Stoetzel, President of the American Association for Zoological Nomenclature (AAZN), an organization formed in 1983 to (1) raise money in the United States for support of the International Commission on Zoological Nomenclature (ICZN) and (2) provide a liaison between the American systematic community and the ICZN. Established in 1895, the ICZN is the only worldwide authority that considers problems of zoological nomenclature and that is empowered to rule on such problems. American systematists generate 25% of the ICZN's workload, and 35% of all cases deal with the class Insecta. All entomologists, regardless of specialization, must know the correct scientific names of the insects with which they are working. Yet, in recent years the finances of the ICZN have been increasingly strained by rising costs and reduced budgets. In her letter, Dr. Stoetzel asks that the Entomological Society of Washington become a supporting member of the AAZN and that it continue its membership on a yearly basis for the foreseeable future. Individual ESW members are also encouraged to join, pledging whatever amount they can afford (generally not less than $20 per annum). Dr. Wood urged the membership to seriously consider this request and announced that he would forward Dr. Stoetzel's letter to incoming President F. Christian Thompson for a decision at the next meeting of the Executive Committee.

Corresponding Secretary J. M. Kingsolver displayed a series of remarkable scanning electron photomicrographs showing apparent stridulatory structures on 3 species of bruchid beetles. In *Acanthoscelides chiricahuae* (Fall) (western United States), the scraper is a ridge on the mesal margin of the hind femur, and the file is a radiating set of fine ridges on the face of the hind coxa. In *Amblycerus eustrophoides* (Schaeffer) (Florida), the scraper is a series of ridged setal bases on the mesal face of the hind femur and the file is a transversely striate ridge on the ventral border of the metepisternum. In *Amblycerus* n. sp. (Mexico), the scraper is a striated tooth on the ventral margin of the hind femur, and the file is a ridge similar to that of *A. eustrophoides* but nearer the middle of the metepisternum.

Program Chairman W. E. Steiner, Jr. and Jil M. Swearingen exhibited a beautiful hammer dulcimer built with genuine worm-eaten American chestnut by Nicholas Blanton of Shepherdstown, West Virginia, and incorporating lifelike models of several arthropods, including one of the Locust Borer, *Megacyllene robiniae* (Forster), over the resonance hole.

R. G. Robbins displayed a copy of a new reference for acarologists, *Provisional Atlas of the Ticks* (*Ixodoidea*) *of the British Isles,* by Kieran P. Martyn, Biological Records Centre, Institute of Terrestrial Ecology, Monks Wood Experimental Station, Huntingdon.

President Wood announced that although Gary Larson will not be made a Fellow of the Entomological Society of America at this year's National Conference in Louisville, a sizable collection of cartoons evidencing this artist's uncanny insight has been assembled as a gift on behalf of the entire entomological community. In Dr. Wood's words, "Gary Larson has probably done more to encourage insect study than anything since yellow fever!"

With a round of applause, President Wood welcomed the return of J. R. Aldrich, our Society's Program Chairman in 1983 and 1984 and our President-Elect for 1989. Dr. Aldrich thanked the Society for its support. He then noted with sorrow the untimely passing of his colleague Elton Warren Herbert, Jr. (November 5, 1943–November 16, 1988), a research entomologist at the Beltsville Agricultural Research Center from 1966 to 1969 and again from 1972 until his death. Dr. Herbert is remembered for his studies of the nutritional requirements of honeybees and for his research on methods to control bee diseases and mites parasitic on bees. Specifically, he worked to develop a substitute for pollen and to formulate chemicals that block the molting hormones of *Varroa jacobsoni* Oudemans without affecting honeybee physiology. Memorial contributions may be made to the Dr. Elton W. Herbert, Jr. Scholarship Fund in care of the Entomological Society of America, 9301 Annapolis Road, Lanham, Maryland 20706.

The speaker for the evening was James M. Hill, Ecologist, Maryland National Capital Park and Planning Commission, whose talk was entitled "Life History Studies of *Cicindela dorsalis,* an Endangered Tiger Beetle." With the ongoing degradation of beachfront in Calvert County and other Maryland jurisdictions, several species and subspecies of tiger beetles have been locally extirpated. Beach-inhabiting species require untrammeled sand in which to complete their development. The onslaught of commercial and residential construction, off-the-road vehicles, and sheer human numbers has rendered much of the Atlantic coast uninhabitable for both tiger beetles and their prey. In an attempt to conserve these attractive insects, Mr. Hill has conducted life history studies focusing on population dynamics, territoriality, food preferences, thermoregulation, parasites and predators. His presentation was illustrated with superb close-up photographs taken by Nate Erwin of this Society and with slides of distribution maps prepared by Barry C. Knisley of Randolph-Macon College, Ashland, Virginia.

President Wood congratulated Mignon Davis and Don Anderson for their unstinting loyalty to this Society. Mignon has been bringing and preparing refreshments for many years, while Don has set up chairs and minded the slide projector for longer than even he can remember! Such members are the linchpins of our organization. With these kind words, Dr. Wood handed the gavel to incoming President Chris Thompson, who adjourned the meeting at 9:20 p.m. Refreshments (including some normally reserved for lightly sclerotized specimens) followed, together with holiday entertainment à la dulcimer.

Richard G. Robbins, *Recording Secretary*

## 945th Regular Meeting—January 5, 1989

The 945th Regular Meeting of the Entomological Society of Washington was gaveled to order by President F. Christian Thompson in the Naturalist Center, National Museum of Natural History, at 8:05 p.m. on January 5, 1989. Thirty-two members and 23 guests were present. Minutes of the December meeting were read and approved.

Membership Chairman G. B. White read the names of the following applicants for membership: Robert Carleton Brown, Morristown, Tennessee; Candy Feller, Department of Entomology, Smithsonian Institution; Thomas O. Robbins, USDA, ARS, Grassland, Soil and Water Research Laboratory, Temple, Texas; and William P. Weaver, Jr., Panorama City, California. Chairman White also reported that the Executive Committee had unanimously elected the following members to Emeritus status: Lauren D. Anderson, University of California at Riverside, who has been with us since 1944; and George R. Manglitz, University of Nebraska, Lincoln, a member since 1956.

President Thompson discussed the highlights of the Executive Committee meeting held earlier in the day. With evident pleasure, he described the Committee's decision to throw down the gauntlet by donating $750 to the American Association for Zoological Nomenclature (see previous minutes). Other priority items on this year's agenda include selection of an Associate Editor, to succeed Hiram Larew in 1990; sale at reduced rates of our vast back stock of *Proceedings* and *Memoirs*; and a survey of the interests and expectations of the entire ESW membership. T. E. Wallenmaier asked whether the Committee had agreed to grant other entomological organizations brief access to the *Proceedings*. Dr. Thompson replied that this matter remains under discussion.

Dr. Wallenmaier described his Christmas sojourn in Alabama, where he encountered the cattail toothpick grasshopper, *Leptysma marginicollis* (Serville), an unusually slender acridid that cryptically clings to grasses, sedges and rushes bordering ponds and watercourses. According to the orthopterist Jacques R. Helfer, this species ranges from Maryland west to Kansas and Nebraska and thence south to the Gulf Coast. Its quick flight and agile dodging behavior make it a difficult insect to see, let alone capture, but collectors have learned to beat wetland vegetation, thereby knocking the grasshoppers into the water, where they are easily retrieved. A pinned specimen was exhibited to the audience.

M. B. Stoetzel displayed a notebook containing copies of numerous cartoons drawn in honor of Gary Larson, who was sent the originals after they were shown at a special exhibition during last year's National Conference of the Entomological Society of America, in Louisville, Kentucky.

The speakers for the evening were Dan Polhemus and Warren E. Steiner, Jr., both of the Department of Entomology, Smithsonian Institution. Their talk, entitled "Natural History of Madagascar, with Emphasis on Entomological Studies Past and Present," was a delicious romp over the length and breadth of the world's fourth largest island (after Greenland, New Guinea, and Borneo), which at 587,041 square kilometers is somewhat larger than France. Climatically, Madagascar is divided into two main areas: a narrow humid belt running along the east coast and separated from the rest of the island by the steep eastern slopes of the central mountains; and a series of western slopes and plains that are characterized by a distinct dry season. In separate but complementary expeditions, Dan and Warren sampled the insect fauna of Madagascar's multifarious biotopes, including the rain forests of the east coast, the remnant deciduous woods of the Central Highlands, the broad savannas of the west, and the thorny scrub of the xeric southwest. According to Dr. Vincent Razafimahatratra, an entomologist and professor at the University of Madagascar, fully 90% of the island's insect species remain undescribed. A tiny sample of this diversity was exhibited in several insect drawers crammed with moths, butterflies, beetles, and other insects that well evoke their mysterious homeland. Each speaker also chronicled his travels with scores of photographs, some so striking that listeners could almost taste the island's red lateritic dust or hear its groves of windswept bamboo. Warren warmly thanked Patrick Daniels, Claire Kremen, and Patricia Wright, all of Duke University, for their logistical support and unfailing camaraderie throughout his expedition.

Visitors were introduced and the meeting was adjourned at 9:25 p.m. Refreshments followed.

Richard G. Robbins, *Recording Secretary*

## 946th Regular Meeting—February 2, 1989

The 946th Regular Meeting of the Entomological Society of Washington was called to order by President F. Christian Thompson in the Naturalist Center, National Museum of Natural History, at 8:07 p.m. on February 2, 1989. Twenty-two members and two guests were present. Minutes of the January meeting were read and approved with one correction.

President Thompson announced that the Executive Committee had selected Robert D. Gordon, Research Entomologist, Systematic Entomology Laboratory, USDA, as the new Associate Editor of our *Proceedings*. Dr. Gordon will succeed Hiram Larew as Editor at the end of this year.

Membership Chairman G. B. White read the name of the following applicant for membership: Jon K. Gelhaus, Postdoctoral Fellow, Department of Entomology, Smithsonian Institution.

Custodian Anne M. Wieber warmly thanked Herb Jacobi, Trevor Lubbert, and Geoff White for taking time from their busy weekend schedules to help her organize and spruce up the Society's vast backlog of *Proceedings* and *Memoirs*.

W. E. Bickley displayed a new book for culicidologists, *The Natural History of Larval Mosquito Habitats,* by Marshall Laird, published in September of 1988 by Academic Press, 555 pages, ISBN 0-12-434005-9, $135.00/cloth.

President-Elect J. R. Aldrich exhibited a postcard on which the sender had affixed a colorful National Wildlife Federation stamp featuring the southern green stink bug, *Nezara viridula* (Linnaeus) (Hemiptera: Pentatomidae). Dr. Aldrich is gratified by public recognition of this species because he has been investigating its physiology for several years.

The speaker for the evening was Past President Gene Wood, whose talk was entitled "Insect Short Stories," some reminiscences and anecdotes of an extension entomologist. Drawing on a lifetime of experience in urban entomology, Dr. Wood recalled his adventures with head lice (*Pediculus humanus capitis* de Geer) on school children, body lice (*P. h. humanus* Linnaeus) on vagabonds, and German cockroaches (*Blattella germanica* (Linnaeus))—not to be confused with the brown-banded cockroach, *Supella longipalpa* (Fabricius), which, alas, has lost its lovely alliterative epithet *supellectilium* (Serville)—in restaurants and apartments throughout the mid-Atlantic region. He also related the results of his research on termite colonies, including observations on behavior, rearing methods, and regulation via growth inhibitors. There appear to be at least six components in effective urban pest management: frequent surveillance; establishment of pest thresholds; accurate and detailed documentation; public education (including regular liaison); enlistment of alternative control strategies; and proper pesticide usage. These factors were illustrated with photographs taken during actual control operations.

President Thompson thanked Dr. Wood and, amid much applause, presented him with a certificate of appreciation in recognition of his service to our Society over the past year.

Mignon Davis thanked Dr. Bickley for offering to tote in the cider this evening and called for additional beverage volunteers. On that refreshing note, the meeting was adjourned at 9:20 p.m.

Richard G. Robbins, *Recording Secretary*

## 947th Regular Meeting—March 2, 1989

The 947th Regular Meeting of the Entomological Society of Washington was called to order by President F. Christian Thompson in the Naturalist Center, National Museum of Natural History, at 8:08 p.m. on March 2, 1989. Twenty-five members and 16 guests were present. Minutes of the February meeting were read and approved.

Membership Chairman G. B. White read the names of the following applicants for membership: Prem Bhatt, Baltimore, Maryland; Richard Duffield, Department of Biology, Howard University, Washington, D.C.; Kenneth S. Frazer, Department of Biology, University of Alabama, Tuscaloosa; Alan R. Olsen, Altadena, California; and J. David Warthen, Jr., USDA, ARS, PSI, ICEL, Beltsville, Maryland.

Lance A. Durden exhibited some local pedilid beetles that are characteristically attracted to members of an unrelated coleopterous family, the Meloidae. While collecting in a section of Patuxent River Park, Prince George's County, Maryland, Lance obtained a single *Pedilus terminalis* (Say) that had attached itself to a living specimen of *Meloe angusticollis* Say. During a field trip of 5 or 6 hours, the pedilid remained firmly joined to the meloid's dorsum but, perhaps predictably, it detached while being readied for photography. In Bethesda, Montgomery County, Maryland, four *P. terminalis* were found clinging to a dead specimen of *Lytta aenea* Say, demonstrating that this peculiar heterospecific attraction does not require a live meloid. Apparently, pedilids are drawn to the cantharidin in meloid hemolymph. Cantharidin is a potent toxin that repels potential predators; it thus seems odd that pedilids, together with their relatives the anthicids, are sometimes attracted to this substance. Dr. Durden thanked T. J. Spilman for his assistance in identifying these beetles and for providing valuable life history information. An animated discussion ensued, during which T. J. Henry, T. J. Spilman, A. G. Wheeler, Jr., and J. R. Aldrich noted that cantharidin has been used by entomologists (among others) to attract at least two subfamilies of Miridae (Hemiptera) as well as ceratopogonid midges (Diptera: Nematocera).

R. F. Whitcomb exhibited a male specimen of an undescribed leafhopper (Homoptera: Cicadellidae: *Limotettix* n. sp.) that feeds on spike-rushes (Cyperaceae: *Eleocharis* sp.) associated with serpentine soils. The specimen was collected on June 20, 1970 in Beltsville, Prince George's County, Maryland, but appears to have been subsequently extirpated there. It still occurs at Soldiers Delight, in western Baltimore County.

President Thompson displayed a singularly interesting book that should not be overlooked by entomologists with a yen for travel. *A Birder's Guide to Japan,* by Jane Washburn Robinson, 1987, Ibis Publishing Company, Santa Monica, California, is crammed with advice on how to conduct field work—and oneself—in a land that is the antithesis of East Coast America. Topics include when to go, what to bring, finding your way about, safety, making arrangements, and getting help. The insightful discussion of good manners might be profitably perused even by stay-at-homes. Scores of detailed maps together with summaries of useful kanji should prove invaluable to entomologists working in rural Japan. As for the Occident, the President also exhibited a flyer from the British Biology Curators' Group exhorting young naturalists to "beetle-down" to their neighborhood museum.

The speaker for the evening was A. G. Wheeler, Jr., whose talk was entitled "Some Insects of Eastern Serpentine Barrens." Serpentine rocks or ultramafics, i.e. igneous rocks containing high concentrations of ferromagnesian minerals but a low complement of silica, yield soils that support an impoverished but distinctive xeromorphic flora characterized by endemism, disjunct ranges, ecotypic differentiation, and numerous morphological variants. To survive on serpentine exposures, plants must tolerate low nutrient levels, high concentrations of toxic heavy metals (nickel, chromium, cobalt), and unfavorable calcium/magnesium quotients that are equally deleterious to animals. No group of "serpentine animals" has received more attention than the insects, which have evolved numerous endemic or quasi-endemic species attuned to the biotic and edaphic strictures of their environment. Among the species discussed this evening were chrysomelid beetles of the genus *Diabrotica,* the lygaeid bug *Blissus breviasculus* Barber, the tingid *Hesperotingis antennata* Parshley, and a suite of striking myrmecomorph mirids: *Schaffneria davisi* (Knight), *S. pilophoroides* (Knight), and *S. schaffneri* Knight. Dr. Wheeler's presentation was illustrated with slides prepared by Tom Smith and Jim Stimmel. Two recent comprehensive texts were also exhibited: *Floras of the Serpentine Formations in Eastern North America, with Descriptions of Geomorphology and Mineralogy of the Formations,* by Clyde F. Reed, 1986, Contributions of Reed Herbarium, No. XXX, Baltimore, Maryland; and *Serpentine and Its Vegetation, A Multidisciplinary Approach,* by Robert Richard Brooks, 1987, Dioscorides Press, Portland, Oregon.

W. E. Bickley announced the availability of a new book, *Nymphs of North American Stonefly Genera* (*Plecoptera*), by Kenneth W. Stewart and Bill P. Stark, with illustrations by Jean Stanger. This work, volume 12 in the Thomas Say Foundation series, is billed as the definitive sequel to P. W. Claassen's 1931 monograph, *Plecoptera Nymphs of America* (*North of Mexico*), and may be purchased by members of the Entomological Society of America for $65.00 (nonmembers $108.00). However, Dr. Bickley perceptively notes that genera do not have nymphs.

As one of its centennial activities, the Entomological Society of America is proposing that the United States adopt a national insect. Recently, their members selected the monarch butterfly, *Danaus plexippus* (Linnaeus), as a candidate for this distinction. President Thompson distributed some "campaign literature" in the form of a colorful ESA brochure describing the monarch's life history and recent collaborative efforts to preserve its overwintering grounds in California and Mexico. Organizations and individuals who would like to help sponsor this project are invited to contact Douglas W. S. Sutherland, ESA National Insect Subcommittee, 9301 Annapolis Road, Lanham, Maryland 20706-3115, or call (301) 731-4535.

T. J. Spilman called the membership's attention to a temporary exhibit of wooden insect sculptures in the Insect Zoo, National Museum of Natural History. Carved from fine woods by Patrick Bremer, these anatomically exact likenesses average three to four feet in length and were featured in the December 1988 issue of *Smithsonian* magazine.

Among our numerous visitors this evening were four members of the Maryland Forest, Park and Wildlife Service—Fraser D. Bishop, Gene Cooley, Katharine McCarthy, and Frank Ryan—who discussed the distribution and biota of their state's serpentine soils.

President Thompson thanked Rich Robbins and Ed Saugstad for bringing refreshments, wet and dry, toward which he adjourned the meeting at 9:25 p.m.

Richard G. Robbins, *Recording Secretary*

## 948th Regular Meeting—April 6, 1989

The 948th Regular Meeting of the Entomological Society of Washington was called to order by President F. Christian Thompson in the Naturalist Center, National Museum of Natural History, at 8:07 p.m. on April 6, 1989. Nineteen members and five guests were present. Minutes of the March meeting were read and approved with one emendation.

Membership Chairman G. B. White read the names of the following applicants for membership, all from Maryland: R. Mark Beach, Hanover; Michael B. Dimok, Columbia; Mary Anne Erickson, Baltimore; Deborah Hahn Fay, College Park; and Mark J. Rothschild, Salisbury.

Past President Gene Wood and Don H. Messersmith circulated a draft of a letter inviting other entomological organizations to publish summaries of their minutes or notices of their activities in our *Proceedings.* The letter reads as follows: "The Entomological Society of Washington is inviting your society to participate in a new cooperative project. We believe that greater cooperation in the dissemination of information among the many entomological organizations in North America could be useful to all of them. Therefore we would like to invite you to periodically submit items of general interest to our Editor for inclusion in our quarterly *Proceedings of the Entomological Society of Washington.* A short paragraph or two would suffice because space is limited. You could include your important society news such as when and where you meet, elections of officers, projects and activities, field trips or other special events, news about members (honors received, promotions, retirements, deaths), speakers at meetings, etc. Our Editor would modify your submissions to fit the space we will reserve for these news items. There will be no charge for this service. Please let us know if you wish to participate in this activity." There were no immediate comments from the membership.

Corresponding Secretary J. M. Kingsolver displayed a valuable new reference for curators and conservators. *A Guide to Museum Pest Control,* edited by Lynda A. Zycherman and John Richard Schrock, 29 November 1988, $36.00/paper, ISBN 0-942924-14-2, is published jointly by the Foundation of the American Institute for Conservation of Historic and Artistic Works and the Association of Systematics Collections. This book provides expert guidance on pest identification and pesticide use in the context of current federal statutes and museum policies. Sections of special interest to entomologists include "Illustrated Guide to Common Insect Pests in Museums," by J.M. Kingsolver (drawings by Candy Feller); "Cockroaches in the Museum Environment," by W.J. Bell; "Biology and Control of Wood-infesting Coleoptera," by W.H. Robinson; "Trapping Techniques for Dermestid and Anobiid Beetles," by W.E. Burkholder and J.K. Phillips; and "List of Insect Pests by Material or Apparent Damage," revised by J.R. Schrock. The work concludes with a partially annotated bibliography on pest control in museums, compiled by Karen Preslock, Branch Librarian at the Smithsonian's Museum Support Center in Suitland, Maryland.

Edd Barrows exhibited a bag of bagworms, *Thyridopteryx ephemeraeformis* (Haworth) (Lepidoptera: Psychidae), which he had collected and reared during the past winter. Few investigators have bothered to conduct laboratory research on this common moth, but Dr. Barrows has found that eggs from Washington-area females collected in winter will hatch in about one month if held at 80°F (27°C).

R.G. Robbins exhibited a set of colorful commemorative stamps from Mozambique belonging to one of this evening's guests, Ralph P. Eckerlin, Northern Virginia Community College, Annandale Campus. These stamps feature paintings of some of Africa's most beautiful tick species: *Amblyomma eburneum* Gerstäcker, *A. hebraeum* Koch, *A. pomposum* Dönitz, *A. theilerae* Santos Dias (= *A. hebraeum*), *Dermacentor circumguttatus* Neumann, and *D. rhinocerinus* (Denny). To the best of the Recording Secretary's knowledge, no other nation has offered its citizens the opportunity to lick a tick. Dr. Eckerlin will attempt to obtain additional sets for entomophilatelists.

President Thompson circulated a brochure announcing the Second International Congress of Dipterology, to be held in Bratislava, Czechoslovakia, August 27–September 1, 1990. This Congress will be organized by the Slovak Academy of Sciences, Comenius University, and the Slovak Entomological Society. Participants are invited to join in dipterological field trips, tours of Prague, a journey to the Tatra Mountains (the highest range of the Carpathians), and even a visit to a Czechoslovakian spa.

The speaker for the evening was Charles Griswold, Postdoctoral Fellow, Department of Entomology, Smithsonian Institution, whose talk was entitled "Natural History of Southern African Social Spiders." Social spiders are a pantropical assemblage of many families. In Africa, several species live along watercourses, where they capture emerging aquatic insects, but others are found in savannas and some occur even in deserts. All share one nest for retreat and construct one large sheet or tangle web for prey capture. No orb weavers or running species are known. Group capture stratagems may enable these spiders to subdue larger prey, but Dr. Griswold's research indicates that the chief benefit of cooperation is a greater diversity of prey. Tactile and chemosensory stimuli probably help spiders distinguish prey from conspecifics. Old prey, vegetative debris, and silk are incorporated into the nest, which consists of numerous interconnected tubes with openings to the outside. Egg sacs are communally guarded, and newly emerged young are fed regurgitated food by females, which may also "adopt" any orphaned progeny. Young spiders do not assist in catching prey until they have reached their third instar. The ratio of males to females is about 1:10, with females founding new colonies either as groups or individuals. All these remarkable behaviors were captured with stunning close-up photographs taken by the speaker's wife, Teresa Meikle-Griswold.

J. R. Aldrich reminded the membership that this year's banquet will be held at the National Museum of Natural History, with dinner in the Associates' Court.

President Thompson thanked Doug Sutherland, who in turn thanked his daughter, for making this evening's cookies. Visitors were introduced and the meeting was adjourned at 9:18 p.m.

Richard G. Robbins, *Recording Secretary*

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# PROCEEDINGS
# of the
# ENTOMOLOGICAL SOCIETY
# OF
# WASHINGTON

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## Volume 91

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